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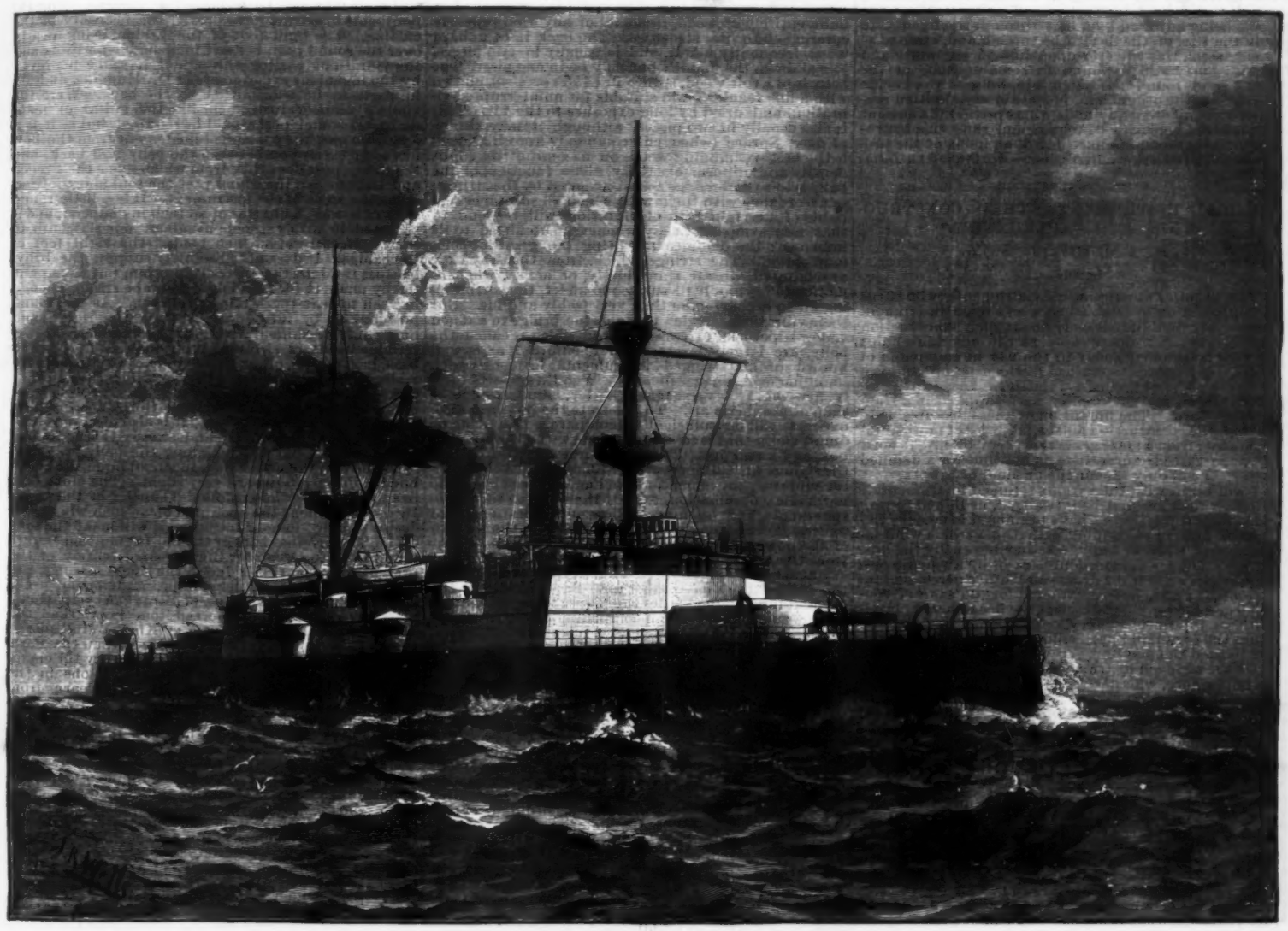
LARGEST TURRET SHIP IN THE WORLD.

AT Chatham dockyard, on July 30, H. M. S. Hood was launched, or rather floated, from the building dock into the adjoining basin, with a ceremony performed by Viscountess Hood, wife of the peer descended from that famous commander Admiral Sir Samuel Hood, who was made Lord Hood for his exploits in the last century. The new ship named after him is one of the eight first-class battle ships called for by the naval defense act. Of these she is the only turret vessel, the others being on the barbette principle. She has been less than two years in hand. It is said that she is the largest turret ship yet built; her floating weight is 7,500 tons. Her length is 380 ft.; breadth, 75 ft.; draught of water forward, 26 ft., and aft, 28 ft.; displacement, 14,150 tons; indicated horse power, 13,000; speed (in knots), 17½. Her armament is to consist of four 13½ in. breech loading guns in turrets, ten 6 in. quick firing guns, ten six pounder quick firing guns, and nine three pounder quick firing guns, besides twenty-four torpedoes and boat, field, and machine guns. Her engines, by Messrs. Humphrys, Tennant & Co., have not yet been erected. The total cost of the ship will exceed $4,500,000. It is expected that in a few months the Hood will be ready for commission.—*The Illustrated London News.*



H. M S. HOOD, THE LARGEST TURRET SHIP IN THE WORLD.

CANT HOOK HANDLES.

AMONG saw mill accessories, one of the most important for its general handiness and utility is the cant hook. While in the woods and on the drive its near relatives, the peevey and pike lever, hold quite as important a position.

The making of the handles for these tools has become quite an industry in several towns in hardwood districts where suitable timber can be found. Hickory and white oak make the best and most serviceable handles, and the supply formerly came from Indiana, southern Michigan, and southern Wisconsin. White ash, pecan, iron wood, rock maple, rock elm, red oak, and beech have all been used at various times and in various sections to meet the local demand. At present the supply comes largely from northern Michigan, and rock maple and rock elm are principally used. A few iron wood and beech are made, but rock maple really makes the best handle. The ash of northern Michigan is apt to be brashy, and is too brittle for serviceable timber.

Cadillac and Mancelona are two of the heaviest traders in the stock. The mills are mostly situated out of town, in the splendid hardwood forests of that section, and are run by men of small means, the jobbers in town furnishing their supplies and sometimes guaranteeing the loggers. A good outfit for making them consists of a small semi-portable saw mill, a drag saw and a long hand-turning lathe or a gauge lathe. The larger number are turned out on the ordinary hand-turning lathe, but wherever the parties can afford it, the gauge lathe that turns to pattern is superseding the other.

If there is no saw mill attached to the outfit, the stock is either rived or split into the proper size or is got out by a bench saw. Sometimes both a saw mill and bench saw are used, the former simply flitching the logs, the flitches being afterward cut the proper length for a handle, and then ripped up on the bench saw.

The process is about as follows: The best sound, straight-grained, clear logs are cut of the right length for two or three handles, and are hauled to the mill, the supply being usually all hauled in the winter on the snow. They are mostly cut from the farmers' lands where clearings for fields are being made. Large numbers are cut and hauled by the farmers themselves, for which they obtain the cash or its equivalent in supplies, often thus obtaining enough from a choice tract of land to pay the entire expense of clearing it. At the mill the logs are first sawed into handle lengths either by a drag saw or by hand, if they are to be either rived or worked over a bench saw. If not they are sawed into plank of the right thickness, the flitches turned down, and then the whole ripped into long square scantling, 3½ by 3½ or 4 by 4, mostly the former. The sticks are then cut the length of a handle, and are sent to the lathe, where they come out finished, ready for the steel attachments.

If there is no saw mill, the logs, as has been stated, are cut into handle lengths, and if for the bench saw, the larger ones are split into halves or quarters by beetle and wedges, and are then sawed into sticks ready for the turning lathe, two operations at the saw being required.

But a large number are got out without the intervention of any saw but a cross cut. The logs being cut to length are split into sticks, instead of being sawed, being first split or rived into flitches and then resplit. The best handles are made from split stock, as only the best logs will split sufficiently straight; and further, any brash or brittle timber will be discovered and thrown out, as it would be too expensive to hew such into shape. But this process of getting out the stock is very wasteful, as the sticks have to be made larger than if sawed, to allow for any irregularities in the grain, and quite a large per cent. is spoiled in the getting out. The most economical method is the combination of saw mill and bench saw, as by that means very large logs can be cut up closely, with little waste, by the larger saw, while many small ones can be worked up by the bench saw that would hardly pay to run through the other, and the stock can be cut to a close size, just large enough to turn.

As has been stated, the most of these are made from rock or sugar maple and rock elm. But occasionally a few are made of white beech, when it is found of sufficient toughness; and what iron wood is found is used also. This latter wood is very tough, and makes a fine handle, but the tree hardly rises above the dignity of a shrub, seldom reaching a diameter of eight inches or a height of 50 feet. It shoots up very straight, and, if large enough for one handle with the heart in

the center, makes a handle that will outwear almost anything that grows.

At certain seasons of the year, especially during the last of the winter, a procession of teams may be seen coming into the towns mentioned from the farmer mills, loaded with the handles. Aside from being a godsend to the farmers in helping them to pay for clearing their lands, the business brings a good deal of trade to the towns. On the other hand it involves a wastefulness of the great hardwood timber wealth of the sections involved that is to be deplored. The farmer or other timber owner will clear an entire 40 acre tract on the strength of the few logs on it good enough for cant hook handles, while all the rest practically goes to waste, though a certain portion of the best that is left is sold for firewood. The bulk is burned on the ground, except in the occasional instances where there are charcoal kilns near by. And this just because there are not other industries developed there that should use up the coarse and rougher and smaller timber. Manufactories, like chair works and the coarser and cheaper kinds of furniture in general, would make a market for the hardwoods of all kinds that would leave but little refuse, and would lead to the utilizing for fuel much of that which is now piled into heaps and burned on the ground.

It requires about seven feet of good lumber for one handle. It is impossible to tell exactly how many handles are made annually in the Northwest; but from data at hand there must be in the neighborhood of a round million, making 7,000,000 feet. As only about 10 per cent. of the timber on the land cleared is utilized, there must not be far from 70,000,000 feet destroyed annually to provide this useful tool.

The cant hook of our grandfathers, and even of our fathers, was a very different affair from the natty one of to-day. It was a long piece of bent steel, something like an exaggerated cod hook, with holes in the shank; the latter ran up through a mortise in the handle, which was a long, heavy piece of oak scantling, the hook being adjusted by a bolt through the handle, to suit the size of the log to be turned; and, strange as it may seem, this travesty upon human ingenuity and progress may still be found in some sections of the South and round the mountain mills of the Pacific coast. On the other hand, in spite of its admitted usefulness, there are many mills where neither the ancient nor modern hook can be found, and thus this instrument really becomes something of an index of the progressiveness of a saw mill section.—*Northwestern Lumberman.*

MUSICAL INSTRUMENTS: THEIR CONSTRUCTION AND CAPABILITIES.*

By A. J. HIPKINS, F.S.A.

Lecture I.

THE inquirer about musical instruments, who turns for information to established works upon instrumentation, will find his curiosity about their construction and development unappeased, as the musician's point of view is directed solely to the use he can make of them. If he turns to musical dictionaries or technical works, he will still remain unsatisfied, because the information is, for the greater part, supplied in a fragmentary form. The intention of these lectures is to explain the construction and capabilities of musical instruments from a more general aspect: briefly, it must be, as in three lectures there is not time for a detailed study. I can only sketch the outlines of a work.

I will begin with the various stringed instruments—whether they are touched, twanged, or bowed to produce their sounds—that have been used in modern European music; continuing with the various wind instruments, wood or brass, whether blown by the lips, by means of a single or double reed, by a whistle or a mouth piece; also the drums and other percussion instruments; and, lastly, gathered for the sake of convenience into a separate class, the instruments played with an intermediary keyboard, borrowing from the wind the organ and harmonium, and from the stringed division the piano.

Of the stringed instruments, the violins are the first in importance, whether it is for power and delicacy of musical expression, fitness for exact intonation, or arriving at structural perfection almost at once, since no change has taken place in the violin from its invention 350 years ago; and apart from its musical value, a well made violin is in form, and often in color, a never-tiring enjoyment to the eye. It is the sum of these fine qualities that justifies the pre-eminence always accorded to the violin family. But in praising the instrument the bow must not be overlooked, as it is indispensable for the production of the tone, and is the means by which the player can impart his personal musical feeling, and take a part in reproducing the masterpieces of the modern masters of chamber music and the orchestra. Unlike the violin, which has changed so little, the bow was improved by degrees until about 100 years ago, when it was fixed and made perfect by the beautiful contrivance of Tourte.

The invention of the violin is attributed to Gasparo da Salo, of Brescia, about the year 1550. There is no certain evidence about the instrument it may be supposed preceded it, and was also tuned, like the violin, in fifths. It may have been a German instrument altered by Italian taste. Attribution to Gasparo da Salo lacks positive evidence, but it seems to be warranted by his place in the order of time. Almost immediately after we find Maggini, the greatest of the Brescian school of violin makers, and Andrea Amati, of Cremona, the latter supplying the French King, Charles IX., with violins in 1572. Amati founded the school of Cremonese violin making, which has been universally accepted as pre-eminent. It culminated in the supreme achievements of Stradivari and Guarnieri del Gesu, in the early years of the 18th century.

The size and proportions of a violin are exactly calculated for a player's arm and convenience, and the lightness of the instrument (for a fine violin weighs, when fitted and strung, only from three quarters of a pound to a pound) is as remarkable as the expressive character and the energy of the tone produced. In the best patterns, excluding the neck, it is not more than 14 inches long, and at the widest part it hardly exceeds 8 inches. The strain of the four strings in the present day depends, of course, upon the thickness and corresponding weight of the stringing. With a heavy stringing it has been given by Mr. George Hart as 62¾ lb., and with a light stringing 52½ lb., the downward pressure upon the bridge being 27 lb. 13½ oz. and 23 lb. 5 oz. respectively; at the modern Philharmonic or English orchestral pitch of 452·5 double vibrations per second, for A, the open note of the second string. But I am not sure that Mr. Hart took into consideration the height of the bridge, which adds to the tension more or less. The first string is tuned a fifth above this A, and bears the greatest strain; hence its penetrating tone quality and also its liability to break. The third string, which should be the most mellow and full in tone quality of the instrument, is tuned a fifth below the second. All these three strings are of gut, and selected from the small intestines of sheep, prepared by a long and very careful process to separate them into threads. Three or four of these threads are spun for the first and second strings and six or seven for the third. The fourth string in a violin is a covered string, that is to say, it is of gut spun over with fine silver or copper wire; the loading of the string is to increase the thickness and weight, so as to make the rate of vibration slower. The accordance is thus: G below middle C, D, and A in the octave above it, and E above C in the treble clef. The strings being all of the same length, have to be made gradually heavier in the order of second, third, and fourth to obtain this accordance. Although these strings are less strained than the first, the making up by thickness is essential, as well for the fullness of tone as for the tension required. It will therefore be seen that, owing to these conditions of uniformity of length and the difference of thickness and tension, the violin, with all its merits, is far from being a perfect instrument, as may be heard when a player has the misfortune to break the first string, and continues with the second for his highest string.

We will now regard the bridge, belly, and back, the sound post, and bass bar. The violin is a resonant box built entirely of wood, no metal of any kind properly entering into its structure. The back is of a hard wood, frequently maple, and is usually in two pieces, joined down the middle, but may be in one piece. The belly is of a soft wood, spruce fir (*Abies excelsa*), chosen with a fine regular grain suitable for uninterrupted vibration, and dried by long exposure to the air. This is also usually in two pieces, although it may also be of one. Spruce (when cut commonly known as deal) is the best resounding wood, on account of its slight density and uniform elasticity. The function of the belly is to re-enforce the sound initiated by the strings, in accordance with the law by which all substances capable of a certain rate of vibration will respond to that rate sympathetically whenever submitted to its influence; the distance not being too great for communication. The strings, which, from the way they are agitated, vibrate transversely, or across, when in motion, offer too little surface to affect the surrounding air to become more than very feebly audible. But their vibrations, carried through the bridge to a much wider superficial expanse of wood which is called the belly, are largely increased or re-enforced, as is well known of all stringed instruments furnished with sounding or resonance boards. Wood, and particularly firwood, is a very much better sound conductor than atmospheric air. To illustrate the power of resonance, it will be sufficient to compare a practicing or dumb violin that is sometimes made without resonance box, and a real one. The wood takes up the sound of the strings with all their proper tones, to the very smallest vibratory movement, as well as the most complete harmonic combination, exactly the same as the atmospheric air, and no more. Thus all vibrations and figures, however complicated, initiated by the friction of the bow upon the strings, are transmitted to us from the wooden box, and completely, if not impeded or quenched by any imperfection in the wood, through the ever-faithful environing air. Suppression of the original force imparted by the player from the exhaustion of energy, and the all-compelling power of gravitation, is nearly instantaneous, a sustained tone being only maintained by the bow.

The back and belly of a violin are connected by six strips of maple, technically called ribs or sides, which complete the framing of the resonance box. They help to transmit the vibrations of the belly to the back, and are attached by means of glue. The curvature of the sides was early introduced in a precursor of the violin, to enable the bow to pass easily across the strings. It divides the shape of the instrument into what are technically called the upper, middle, and lower bouts. Both back and belly are vaulted more or less in opposite directions, according to curves which have been empirically determined by the influence this vaulting has upon the tone. It also offers a certain mechanical resistance to the strain and pressure of the strings. But the building up is materially assured by the blocks—six small pieces of spruce, or it may be of lime or willow, shaped and glued into the instrument: four at the four pointed corners of the C's, or middle bouts, one at the top, and one at the bottom. They are set perpendicularly as regards the grain. There are also twelve strips of spruce, lime, or willow, called side linings, which connect the blocks together, and bind the resonance case into a homogeneous structure. The dark lines round the edges of the back and belly, apparently ornamental, are called purflings, and are inlaid in 24, sometimes 36 pieces. The *f f*, or sound holes, are very noticeable features in a violin. Their shape is due to the vaulting of the belly, and, like the vaulting, varies with the intention or fancy of the maker. They are characteristic of the violin family from its origin. They are cut symmetrically, on either side of the bridge, and their first intention appears to have been to give readiness of response—technically, speech—to the belly. They weaken it, to a certain extent, as the pressure of the bridge comes between them; but that loss is made up by the resistance of the sound post and bass bar. It is also a feature of the sound holes that vibrating air contained within the resonance box escapes through them. This air is set in vibration by the wood which incloses it, but has a shape or form of vibration determined by that of the instrument. If the sound holes are too large, the pitch of this air rises, and the tone of the instrument becomes shrill; if too small, the pitch flattens, and the tone becomes dull. So the shape, size, and position of the sound holes are clearly no more arbitrary than anything else in a violin. By a happy disposition the proper note of a violin, as a resonance box, behaves as a general re-enforcer, helping any note that happens to be played. The late Dr. A. J. Ellis and I made several trials of good violins by means of tuning forks of various verified pitches, in each instance proving this curious fact. The maximum of air re-enforcement was found to be about C in the treble clef, at a medium pitch, reckoned at 528 double vibrations per second, an approximate mean between the Paris normal and the London Philharmonic or Kneller Hall pitches (C 517·3, C 538). The bridge is of maple, with horizontal grain and of medium hardness, and should be about half as thick at the top as at the feet. Its peculiar design, apparently arbitrary and proceeding from the workman's taste, is really an empiric cutting presumed to have been fixed in its present form by the great Stradivari, and to depart from it ever so little in any direction is found to be prejudicial to the tone. Bridges have come down, however, of the Amatis, which are nearly of the same form. The adjustment of the bridge, as indeed every part in a violin, is of the greatest importance. If it is too thick, the tone becomes dull and difficult to produce; and if too thin, the tone becomes shrill and disagreeable. It must be remembered that the higher the bridge the greater is the tension, and that the height has to bear a certain relation to the thickness of the belly, all very nice points that only the greatest skill can deal with successfully. The feet of the bridge have to fit the vaulting of the belly. The top is rounded to prevent the bow touching more than one string. It would seem that the bridge being cut out across the belly, and resting upon the feet, is due to the center line along the belly where the wood joins, or even if it is in one piece, being a node—that is to say, a line of no vibration, but at the same time a line of maximum of molecular condensation or rarefaction, from which vibrations start. It is therefore of importance that this node may not be weighted or coerced. The experiments of Savart have proved the necessity of the cutting. The right foot of the bridge being nearly over the sound post, is itself in a nodal position, and the vibrations passing through it have been proved by the ingenious experiments of Dr. Huggins, at least in part, to be transmitted to the back. Were the violin a *pizzicato* instrument like the guitar or mandolin, no sound post would be required, but as it is a *sostenuto* one, the continued incitement from the bow has to be carried on between the belly and back, and the sound post does this, from which office the French and Italians call the sound post the soul and the Germans the voice of the instrument. It is a little round stick of spruce, a quarter of an inch in diameter, and is adjusted to firmly touch at about one-sixteenth to three-sixteenths of an inch behind the right foot of the bridge. It does not absolutely support the belly, because it might then arrest vibration, but it is practically made to fit. A violin should be strong enough in itself to bear the strain of tension. As the sound post has to be introduced through the right hand hole, only a skilled hand, with experience to determine its exact size and position, can fit it. The bass bar is the other great tone regulator of the violin; it governs the elasticity of the belly, and increases it by the formation of a greater number of nodes or centers of no vibration, thus affecting both quality and carrying power. It is also of spruce, and is about 10½ inches long and two-sixteenths in diameter, and should extend along the belly, to which it is glued on the under side, in an oblique direction, but the deviation inward very slight. The glued edge has to follow the longitudinal vaulting of the belly. Its depth is about three-eighths of an inch where it is deepest. If too long or too large, it will make the tone dull. The original bars of the old Italian makers are found to be too weak for the increased tension of the present day, and this is due to the thicker strings, the higher pitch, the higher bridge, and longer neck. The pitch usual in the time of Stradivari and Guarnieri was at least a diatonic semitone lower than the present English Philharmonic or Kneller Hall pitch; that is to say a quarter of a tone lower than the Paris Diapason Normal. But in the 17th century the chamber or secular music pitch, from indications in the vocal music of the time, and as we learn from Prætorius, who published his book in 1618, was about a tone and a half sharper than the very low pitch which followed it. So that the pitch Stradivari constructed his instruments for differed from that which was incumbent upon the Amatis, and probably upon himself in his early days. When we consider such important changes as the altered pitch and the ageing of the wood, combined with the difference of the bow and style of playing, it becomes impossible to recall the impression made by the tone of the Cremona violins, when new, upon contemporary ears.

The neck and head are cut from a block of maple, and have to be set with due reference to the strain of the strings, which are attached to the pegs in the head. The necks of the old Cremona violins have now, on account of the use players make of the shifts, to be somewhat longer, and new ones are accordingly made and fitted to the head. The various fittings, such as the fingerboard, tail piece, nut and tail pin, are generally of ebony, but other woods have been used. Although ebony answers very well for the pegs, rosewood is often preferred to it, but really boxwood is the best. A very important fitting is the fingerboard, the measurement of which is given as 10⅜ inches length and breadth of 1⅝ inch at the bridge to ⅝ inch at the nut. It is rounded to agree with the shape of the bridge; the distance at the lower end between the strings and fingerboard decreasing from the fourth to the first string. It is three-sixteenths from the fourth string and one-eighth from the first. Stradivari, for a violin of 14 inches, placed his bridge from 7⅛ to 7⅝ inches from the top of the body. Seven inches five-eighths is the average measurement. The grain of the fingerboard runs parallel with the strings, but the nut which surmounts it, over which the strings have to pass clear of the fingerboard, is cut across the grain.

There is no constructive difference but that of dimensions between the three sizes of the members of the violin family, the violin proper, the tenor or viola, and the bass or violoncello. In the violin quartet the second place is taken by the violin proper, but the difference heard is considerable, owing to the second instrument being played in a lower part of the accord-

* Two lectures before the Society of Arts, London 1891. From the Journal of the Society.

ance. The instrument which takes the third place is the viola or tenor, which varies more in size than any other fiddle of the quartet. The size which is found to suit the convenience of the average player, and give the proper quality of tone, is from 16 to 16½ inches. It is a fifth lower in the accordance, the open notes of the strings being C and G below middle C, and D and A above it.

For the convenience of manipulation the size of this instrument is restricted, and it is consequently too short for the weight of stringing, an imperfection that causes the peculiar quality of the viola tone. The two lowest strings are overspun. There is reason to believe that a large viola or tenor was the first four-stringed fiddle made, and that the violin was the diminutive of it. There has been an attempt recently made to revive the use of the large sized tenors, such as were made by Gasparo da Salo, the Amatis, and other Italian makers, but perhaps owing to the large grasp required, the viola alta, as it has recently been called, has not been generally accepted, nor does it appear it will be.

The violoncello is the bass violin. Comparing measurements made by M. Vidal of admittedly fine instruments, the violoncello body is rather more than twice the length of the violin—2 feet 5½ inches against 14 inches; and the breadth at the widest part, the lower bouts, follows the same proportion, viz., 1 foot 5⅛ inches nearly, against 8¼ inches. The standard length of body is, in fact, 2 feet 6 inches. It is one octave lower in pitch than the viola; the accordance is C below, and G, D, and A in the bass clef. The wider finger board renders a different fingering necessary, the aid of the thumb being brought in for the higher positions.

The harmonics, which are of very full sound, and the *pizzicato*, which is very effective, are much admired. But far above these excellences the tone of the A string is before all in instrumental music for passionate expression. While the viola was in use as early and perhaps earlier than the violin, the violoncello came later. It existed, however, in Italy and in Holland in the early part of the 17th century. Its first use was with the other bass instruments in the basso continuo, then of recent introduction, and an invention powerfully influencing the progress of musical composition, but the difficulties of execution prevented anything like solo employment for a long while, or any competition with the favorite bass viol, the viola da gamba. The violoncello was for a long while of varying dimensions; Stradivari, in his fine period, determined the existing model.

In the modern orchestra the double bass, the Italian violone or big viol, goes with the violoncello, but an octave lower. By its musical position it might form one of the violin family, but it does not altogether as an instrument, having considerable likeness to the viols; the sloping shoulders are, however, necessary to the performer.

Gaspar da Salo, who is accredited with the invention of the violin, made double basses, and so also did Maggini; Messrs. Hill & Sons have one by this maker in their possession. The accordance of the double bass is, in England and Italy, three stringed—A D below and G first space in the bass clef. Elsewhere it is four stringed—E, A, D, G—and this accordance is rendered a necessity by modern composers; yet the three stringed viol tuning being the original, as well as on account of the greater sonorousness, favors its retention by double bass players. In the Crystal Palace band the three and four stringed basses are equally divided.

I have not, so far, insisted upon the beauty of form and delicacy of curve a fine violin presents, nor its exquisite color; these are not really included in my scheme, but yet have too great an importance to be entirely passed by. At first we wonder if they can affect the beauty of the tone! Certainly a fineness of work that seems almost intuitive, so difficult has it been to imitate; and the lovely varnishing, now regarded as a lost art, must contribute to it. If the work is not carried to the utmost fineness and exactness, in any and every detail, the result suffers. The late Mr. Charles Reade, in a communication some years ago to the *Pall Mall Gazette*, has given his opinion upon the question of varnish thus: "It is not an amber or a spirit varnish alone, but an oil varnish which contains a transparent gum, several times repeated, until the pores of the wood were all filled up. Then several applications of a spirit varnish, holding a coloring matter in solution, gave the exquisite result." He continues: "The beauty, therefore, of varnish lies in the fact that it is a pure, glossy oil varnish, which serves as a foil to a divine, unadulterated gum, which is left as a pure film on it by the evaporation of the spirit in which it was dissolved. The first is a colorless oil varnish which sinks into and shows up the figure of the wood; the second is a heterogeneous spirit varnish, which serves to give the glory of color, with its light and shade, which is the great and transcendent beauty of a Cremona violin."

This passage, and more, of Mr. Reade's letter will be found in Mr. Heron Allen's "Violin Making as it Was and Is," pp. 171–2 (London, 1884), a work to which I am much indebted, as well as to Mr. George Hart's "The Violin: Famous Makers and their Imitators" (second edition, London, 1884), and Mr. E. J. Payne's articles in Grove's "Dictionary of Music and Musicians," upon the violin and its congeners.

Mr. Heron Allen accepts Mr. Reade's theory as a sufficient one, but Mr. Payne, so far as I can gather from his writings, separates the discovery and use of spirit varnish from the older oil varnish. Mr. Hart shall sit in judgment, so far as it can be given. He says, "That the varnish does influence the tone there is strong proof, and to make this plain to the reader should not be difficult. The finest varnishes are those of oil, and they require the utmost skill and patience in their use. They dry slowly, and may be described as of a soft and yielding nature. This common varnish is known as spirit varnish; it is easily used and dries rapidly, in consideration of which qualities it is generally adopted in these days of high pressure. It may be described as precisely the reverse of oil varnish; it is hard and unyielding.

"Now, a violin varnished with fine oil varnish, like all good things, takes time to mature, and will not bear forcing in any way. At first the instrument is somewhat muffled, as the pores of the wood have become impregnated with oil. This makes the instrument heavy, both in weight and sound; but, as time rolls on, the oil dries, leaving the wood mellowed, and wrapped in an elastic covering, which yields to the tone of the instrument, and imparts to it much of its own softness. We will now turn to spirit varnish. When this is used, a diametrically opposite effect is produced. The violin is, as it were, wrapped in a glass, through which the sound passes, imbued with the characteristics of the varnish."

Mr. Hart's description is not exactly final; he prefers to leave each one to form his own opinion. I may be allowed to repeat his judgment in other words, viz., that the saturation of the wood by oil quenches the re-enforced continuance of the discordant higher partials of the strings, leaving the less evanescent lower partials to make their satisfying effect upon the ear; while glazing the instrument with a spirit varnish has no such beneficial effect. Mr. Hart ventures to suggest the possibility of the particular gums used having ceased to be obtainable. There are still pure oil varnishes to be obtained; but the question of time and expense seems to preclude their use.

We will now turn to the capabilities and intrinsic value, musically, of the violin family.

As a color is, in itself, a beautiful thing, or is one we are indifferent to, or may even avoid, so it is with musical sounds; and I should be disposed to put back the dawning of music to some such pleasure in hearing a musical sounding note, rather than the chaining together of distinct musical sounds in scales, modes, melodic types, or real melodies. These came, possibly, later, although before the dawn of history. Simultaneous notes, or harmony, however simple, are comparatively of yesterday.

It is the charm of tone quality, or its pleasing individuality, apart from rhythm, that is the first element of lyric beauty. Now, it is more a penetrating individuality than a persuasive charm that characterizes the tone quality of the very finest violin. By shifting the hand along the finger board an upward extension of compass carries with it an enormous increase of dramatic power; and the violin has the remarkable attribute of an increase in effect nearly commensurate with the increase of the number of violins employed, so that with his congeners, the viola and violoncellos, the violin family becomes the acme as well as the basis of the orchestra.

The middle register of the viola has a fine quality of plaintive, almost complaining expression, but the song of a violoncello is inexpressively lovely, and of several violoncellos combined, is far and away the most touching *cantabile* in the symphony. With, however, all this brilliancy and power, there is a gentler and more intimately sympathetic tone-quality latent in a chest of viols—at least, for domestic use. These instruments are the elder cousins of the violins, and had the start by a century or more; then for a century there was a rivalry, in which the violin family became at last the victors. In the struggle for existence the most powerful wins; and so it has been between the violins and viols. The truth and fitness of these remarks will be proved by a performance of 17th and 18th century string music which Mr. Dolmetsch and his pupils will play at the close of this lecture with viols and then with violins. Leaving out the double bass as possibly belonging to both families, the viols are, like the violins, divided into three sizes—the treble, the tenor, and bass viols—the last being the once favorite viola da gamba, which appears to have a chance of being resuscitated, like certain other old and now obsolete instruments having special tone qualities; indeed, there is a professor of the viola da gamba in a musical directory for 1891. The soft and gentle character of the viol tone was particularly fit to blend with the lutes and other plucked stringed instruments that were in contemporary use. The viol differs from the violin in having nearly flat tables, the back one sloped off from the neck, and high ribs; the sound holes being at first *c c's* instead of *f f's*, segments of the old single circular sound hole which is still retained in the guitar and mandolin, as it was in the lute and theorbo. The *f* has been designed from the crescent *c* by reversing the lower member. Another form of sound hole, known as the "flaming sword," a double bending of the line which afterward formed the *f*, was always maintained in the viola d'amore, while the viola da gamba kept to the reversed *c*. Mr. Payne credits Stradivari with the introduction of the violin sound hole into the smaller viols, in which other Italian makers followed. Mr. Hart places this change much earlier. The violin never had frets to mark off the stops; the viols, it may be said, always. It must be remembered the viols with their five, six, or seven strings, tuned in fourths, with the exception of one major third to preserve the diatonic relation, were like the lutes, more available for harmony than the violins, which always tended to melody, or one part only, their origin being possibly in the crowd and rebec, instruments of the people and of popular tunes. All the strings were gut, and the frets were never more than seven. We have record for the accordance for six-stringed viols from Ganassi del Fontego ("Regola Rubertina," Venice, 1542) to John Playford ("Introduction to the Skill of Music," London, 1697), lasting the same for more than one hundred and fifty years. For the treble viol D, G, in the bass clef, middle C, E, A, and D, in the treble clef; for the mean, or tenor viol, C, F, A, in the bass clef, D above middle C, and G in the treble clef; for the bass viol, D below, and G, C, E, A, in the bass clef, with D above middle C.

It would seem as if the double bass had been tuned a fourth lower than the bass viol, and was afterward lightened of the three higher and useless strings. This is Mr. Payne's plausible suggestion. There were, of course, variations in the accordance according to the fancy of the player, to whom, in this respect, some license was given. The tenor viol was sometimes made in two sizes, contralto and tenor, and in Italian it bore the names of viola "da spalla" or "da braccio," the shoulder or arm viol, which explain themselves. The bass viol was "viola da gamba," the leg viol; it was made in three sizes, the largest for concert or "continuo" playing—one of the instruments that played the thorough bass; the medium size, "the division viol," for solo performance of variations, then called divisions; and the smallest the lyra viol, played from the special tablature or lute notation, and, therefore, presumably one of the lute concert. In the last century the treble and tenor viols were reduced in the number of strings, until at last they approximated to, and were ultimately beaten off the field by, the treble and tenor violins.

One variety, however, of the tenor viol has, like the bass viol, a chance of being restored to favor. I speak of the viola d'amore, a tenor viol with sympathetic strings of fine steel wire stretched beneath the gut strings, and vibrating, not from contact with the bow, but by influence. The effect of this has the tendency to affect the imagination like a piano being set free to vibrate by the pedal. The accordance was that of the old tenor viol; and that has been resumed by Mr. Dolmetsch, who finds it more useful than the common chord, or "harp way" tuning, as they used to call it, adopted by the French violinist, Urhan, who induced Meyerbeer to write an *obbligato* part for this instrument, to accompany Raoul in his first song in the "Huguenots." It was then this interesting instrument was revived; but it is chiefly of late years it has come again into notice. The carved head of this viol has, usually, bandaged eyes; it may be to represent love. The violone d'amore was called the baryton, or viola da bordone, the significance of bordone being drone, possibly because there were, as well as the sympathetic strings, some extra open strings the player could touch with his thumb. An early form of baryton was known as the viola bastarda.

The latest phase of the violin has been its commercial and mechanical manufacture, which, against much that is to be regretted, has had the merit of placing the instrument within nearly every one's reach, so that there is no reason there should not be a fiddle in every house; and, if it were more generally taught to the young, in addition to singing, England might have the advantage of becoming a much more musical nation than it is. Mittenwald, in Bavaria, Mirecourt, in Lorraine, and Markneukirchen, in Saxony, are the chief seats of this wholesale fiddle manufacture. Mirecourt produces, for quality, the best of these cheap instruments. The models are those of Cremona with all; and Mr. Payne asserts, with reference to fiddles sold for a few shillings at Mirecourt, that it is certain that one of them, carefully set up, can be made to discourse very tolerable music. Of course, better prices always command better results. Excellent violins are still being made in London and Paris. I need not specify our well known London makers, except to add to authorities I am under obligations to in preparing these lectures, Messrs. Hill & Sons, of New Bond Street, a firm making great efforts to restore to England the good repute it formerly enjoyed for violin making. Messrs. Hill have very kindly let me have a selection of parts of a violin, to serve as examples for what I have endeavored to explain.

To show the difference between viols and violins, Mr. Dolmetsch and his pupils will play two pieces; for viols, a courante, air and saraband, from the "Consort of four parts," by Matthew Locke; and for violins, an adagio and minuet, from a quartet by Haydn. The viols are, a five-string treble one, by Guersan, Paris; a six-string treble, by Feyzeau, Bordeaux; a five-string tenor, probably by Simpson, London; and a six-string viol da gamba, which will be played by Miss Helene Dolmetsch, by Barak Norman, London, of the year 1702. The violins are by Guadagnini and Cuypers; the tenor, Betts; and the 'cello probably old German, although labeled Amati. Mr. Dolmetsch has also brought with him a seven-string viola d'amore, by Johann Hadl, Regensburg, 1720; and a seven-string viola da gamba, also with sympathetic strings, by Carlo Bergonzi, Cremona, 1720.

As it is my intention to complete my review of stringed instruments this evening, I will now turn to the harp and guitar; the only instruments remaining in use that are plucked with the fingers; the last, in fact, of a class of instruments that prevailed during the 15th, 16th, and 17th centuries. The only harp now used is the double action harp of Sebastian Erard, of which by an ingenious pedal mechanism the pitch can be raised a semitone, that is from C flat, in which the instrument is set, to C natural, and again by a second semitone to C sharp. This harp, as an instrument of fixed tones, more nearly approaches our theoretical or written music by separate flats, naturals, and sharps, than any other. Any passages may be repeated in any key with the same fingering, but it can hardly play the chromatic scale, or certain arpeggios that are of chromatic formation. The strength of the instrument lies in its sympathetic tone quality, and in its great power of full sounding arpeggios. The harmonics obtained by touching the middle of the string with the thumb are very beautiful. The mediæval harp had no transposing mechanism. The first step toward it was screwing hooks into the neck or comb, which could be bent back upon a string to sharpen it. About the year 1720, Hochbrucker, a Bavarian, invented the first pedal mechanism. The Cousineaus, who were Frenchmen, improved upon it in 1782, doubled the pedals, and produced the first double action harp. They changed the open tuning from E flat to C flat. The merit of Erard's invention is the admirable ingenuity shown by him in contriving a system of disks to act upon the strings successively with a partial revolution, the first movement of the pedal serving to shorten the strings to produce the first rise of a half tone, and the second movement to attain the whole tone. The position of the upper disk, which is the second to move but the first to act upon the strings, not being changed when the lower disk completes its movement of revolution by stopping the next half tone. For this Erard needed seven pedals only, the same as in the older single action harp. It is not necessary to keep the foot pressed down upon a pedal, as it may be fixed in a notch.

Besides this action, Erard transformed the neck, which had been cut from a solid piece of wood, into a gluing up of several pieces, which insured the grain running as he desired; and the sound body, bearing the sound board, which had been joined up of seven or nine pieces after the fashion of a lute sound body, he made with fewer joinings and with four transverse bars. Recent composers for the orchestra have made valuable use of the harp, which more than compensates, from a musical point of view, for the neglect of it by amateurs. The guitar and the now obsolete lute are certainly of Eastern origin, and the guitar carries some part of its history with it, as the incurved sides point to a time when the instrument it is derived from was indifferently sounded by touch or bowing. No doubt a raised bridge determined this guitar fiddle into an ancestor of the tenor viol. The guitar bridge

proper is combined with the string holder, upon which a sharp edge allows the string a definite vibration, which is carried through to the belly. As there is no sustained vibration, there is no sound post. The circular sound hole is mediæval. The back and ribs are usually made of maple, ash, service, or cherry tree, sometimes veneered and inlaid with rosewood and other fancy woods, and even with ivory. Modern guitars have six strings, three of gut and three of silk, spun over with silver wire. The accordance is E below and A, D, and G in the bass clef, B next to, and E above middle C. The strings were formerly in pairs. Metal screws have replaced the wooden pegs of the true Spanish instrument. The spun strings are twanged with the thumb, the gut strings with the first, second, and third fingers, the little finger resting as a support upon the belly, which, in real Spanish instruments, has frequently a guard of tortoiseshell or other hard substance inserted. The finger board is marked with frets. The use of the guitar is chiefly for accompaniment, either of the voice or of the shortened guitar, and the other truly Spanish instrument, the bandurria. This is also flat backed, but is played with a plectrum, like a mandolin, and with similar *sostinente* effect, got by rapid repetition of a note on the melody strings. The bandurria has three notes of gut, and three notes of spun strings, in pairs, with the accordance G, C, F, G, in the bass clef, and E, A in the treble. Spanish Estudiantina in London, in 1879, and again in 1889, were bands composed of several bandurrias and a few guitars of various sizes, having, as well as the ordinary guitarra, the octavilla, or octave guitar, the laude-citara, or wire-strung guitar, and the guitarra-baja, a large bass one. Their national dances so played are very interesting and pleasing, and frequently of Oriental character.

The Portuguese machete is an octave guitar, strung with four strings, D below, and G, B, D, or E in the treble clef. It is a favorite instrument in Madeira. Bands of these little instruments accompanied by a guitar are to be met with there.

The wire-strung English guitar is one of the cithers once very common in France and Italy, as well as in this country. It is smaller than the guitar, and has an oval body with a flat back. The wire strings were always in pairs, but, when spun strings were adopted for the lower notes, they were single. The tunings were various; but at last the "harp way"—C, E, G bass clef and C, E, G an octave higher—suited the simple accompaniment required, the thumbnail, and probably that of the first finger, being used for plectra.

Concerning other and older accordances, I must content myself by referring to Carl Engel's "Musical Instruments in South Kensington Museum" (London, 1874), or to Lavoix's "Histoire de l'Instrumentation" (Paris, 1878). The now well known South German zither is a rather hybrid instrument, being apparently derived from the horizontal psaltery or dulcimer, played with a plectrum, and the true zither, of which it has the finger board and a ring plectrum, while the bass strings are touched by the fingers. Thousands of these instruments are made annually in Germany. The streich or bow zither combines the viol instead of the cither. It is obsolete, but in the viola zither and philomele has been improved and reintroduced by Herr Curt Schulz.

The last remaining descendant of the lute family is the mandolin, a pleasing stringed instrument that has again come into favor. It is in its present form a later development of the soprano of the mandola or mandora, as the pandurina was the soprano of the lute. The mandora and the lute are pear shaped instruments without the ribs which a flat backed instrument requires. Mandora and lute are differentiated by the stringing, which on the mandora is wire or wire and gut, and on the lute gut only, the mandora strings on account of the wire being struck with a plectrum; the lute strings twanged by the fingers. These instruments, in the 15th and 16th centuries, were made in families, like viols and various wind instruments. The present mandolin is the Neapolitan, an 18th century instrument, tuned like a violin, in fifths, but with fretted finger board. The accordance enables any one familiar with the violin to stop the mandolin easily. What remains difficult is the management of the plectrum and those ethereal *sostinente* effects got from the melody strings by rapidly repeating a note. The predecessor of the Neapolitan mandolin was the Milanese, with five or six pairs of strings tuned in the viol and lute accordance of fourths and a major third. As to the lute itself, which is now rarely to be met with as an instrument even in museums, no *pizzicato* stringed instrument could surpass it in charm of dignified, full sounding tone. The tenor lute was the favorite stringed instrument of the 16th century. For a long while it had eleven strings, tuned G, C, F, A in the bass clef, and D above middle C, G in the treble clef; the highest, the chanterelle or melody, string being single. With a low pitch this accordance was placed a note higher. Toward the end of that century, the requirements of the then newly invented monody and thorough bass accompaniment led to open strings being added to the bass, called diapasons, which descended in scale as low as C below the bass clef, and in bass lutes A or G. There was subsequently what I may call a D minor tuning, which became the most used; I will quote it from Baron (Nuremberg, A. D. 1727)—diapasons C, D, E, F, below, and G in the bass clef; accordance A, D, F, A, in the bass clef, D above middle C, and F in the treble clef; but he wisely remarks in his book, "the tuning upon any instrument which allows the artist most scope, freedom and variety, with most ease and familiarity, to express his conceptions most fully and completely, without limitation or restraints throughout all the keys, must be accounted the best." One characteristic of the lute was the neck bent back at an obtuse angle, derived from its Arab ancestor, with the tuning pegs inserted sideways in the head. This differed from the guitar head, the angle of which was much less pronounced and the pegs pierced the head from the back. The oldest cither head was upon a scooped out semicircular neck like the primitive rebec. The object of the sharp angle was to give bearing upon the nut or chief fret (*capo tasto*); there were at last nine frets of gut bound round the neck and finger board besides adjusted in semi-tones. But the increase of tension due to the very high pitch which obtained in the early years of the 17th century was a great strain upon an instrument with a very thin spruce, cedar, or cypress belly, no ribs or blocks of any kind, and a body built up of similar resounding wood, in slender staves 6, 9, 12 or more in number. Still the bass was not powerful enough for the "continuo," and a great step to assist it in this direction was made when about A.D. 1600 the theorbo, or double-necked bass lute, was invented. Now the diapasons or non-fretted strings were no longer double strings, but single ones of greater thickness, and this led to the substitution of single strings throughout. Some possessors of large lutes with many double diapsons had their instruments altered into theorbos, theorboed lutes they were called, and in the correspondence of Constantine Huygens, a delightful work published at the Hague, and edited by Jonkbloet and Land, the musical part by the latter, we find Huygens seeking such a large lute for transformation. The Paduan was the true theorbo, an instrument about five feet high; the arch lute of modern French and Italian writers, which the German Prætorius and Baron call chitarrone, of six feet high or thereabout, was also known as the Roman theorbo. I believe the Italian arch lute was simply the double gut strung theorbo, and the true Italian chitarrone, the wire strung theorbo. The interest in these tender instruments has passed away, perhaps not to be revived. They bear no relation to the stress of our modern life, but if we turn to our older music, our older poetry and literature, we seem to come nearer to them, and Shakespeare's Dowland is not a mere name.

(*To be continued.*)

THE OLD RAG INDUSTRY.

THE debates on the subject of the new customs duties bring to light the immense diversity of the problems of political economy, the solutions of which will probably proceed from the clash of the free trade and the protection doctrines. Our intention is not to guide our readers through the arcana of the science created by Antoine Montchrestien, but rather to make known certain industries that the greater part of the public is ignorant of, and the interests of which are brought in-

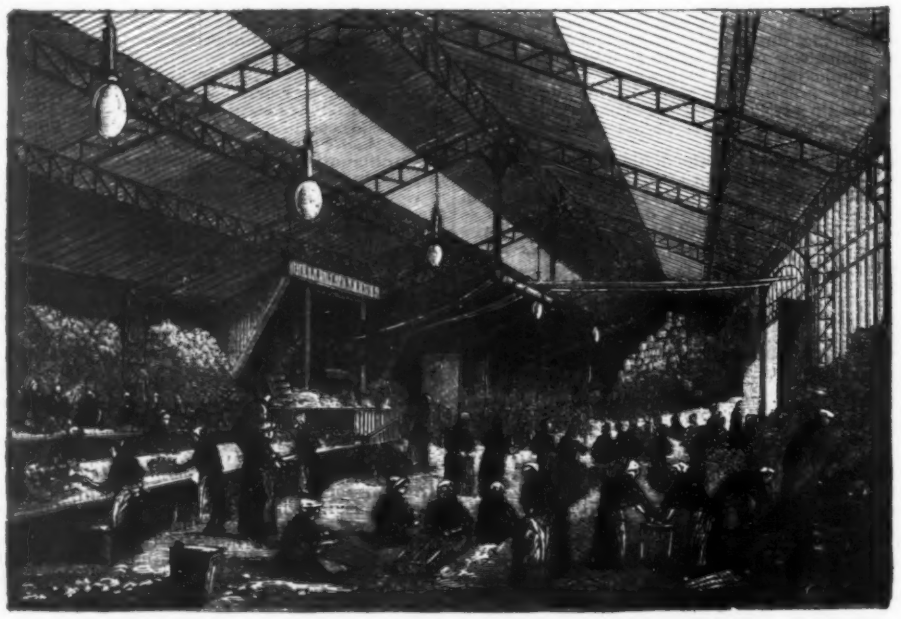


FIG. 1.--HALL FOR SORTING RAGS, CRIMEA STREET, PARIS.

to question in consequence of the duties by which they are menaced.

We desire to speak at present of the trade in old rags and the industries connected therewith, which were in a flourishing state fifteen years ago, but which are now in jeopardy, threatening the ruin, by this fact, of a population whose importance merits some solicitude on the part of our legislators. In fact, the number of persons living on or participating in the commerce of waste products amounts in France to 284,861, distributed thus: Paris, 73,045; suburbs, 11,730; departments, 195,086; Algeria, 5,000.

In this figure are included the rag pickers, the seekers of bargains, the brokers and the employes, to which may be added the dealers in clothes and the workmen employed in reducing rags into first stuff, to the number of 15,175, making a total of 300,036 individuals specially occupied in the handling of rags. But this is not all; there must be included in these statistics the manufacturers and workmen engaged in the conversion of rags into paper, garments, etc., and, finally, those engaged in the commerce of broken glass, rabbit skins, scrap iron, bones, old fat, and, in a word, the dealers in all the namable and nameless waste products, and we reach the figure of 500,000 persons whose sole means of existence lies in the handling of waste products.

It is impossible to form any exact idea of the means employed, and all based upon chemistry, for utilizing the most repulsive detritus. Thus, the establishments in which horses are skinned and cut up, furnish us with a fertilizing material and with cyanides, prussiate of iron and Prussian blue; the blood of slaughtered animals gives a carbon which serves for the clarification of sirups, and the leg bones give us neatsfoot and caballine oil.

There is a class of individuals who get a living by collecting drowned animals. A dog in this state yields 3 or 4 francs' worth of grease, skin, bone, etc.

Up till recently, it was the custom to bury animals that died of charbon. This constituted a permanent danger, as the *Bacillus anthracis*, or microbe of charbon, rising to the surface of the earth, was absorbed by cattle. Now, thanks to a process pointed out by Mr. A. Girard, the eminent professor of the Conservatoire des Arts et Metiers, these elements of contagion are converted into an excellent fertilizer containing 36 per cent. of nitrogen and 6 per cent. of assimilable phosphoric acid. We cannot expatiate to a greater length upon this subject, which would require a special article; nevertheless, it is interesting to note that in England the offal derived from the sweeping of the streets is a source of energy, which is obtained by burning it in special furnaces. The ashes due to the combustion are used as a fertilizer. In America, the smoke which is usually dissipated in the atmosphere is collected and then treated, and products of great value are extracted from it. In Austria there is an establishment that manufactures an excellent paper from the excrement of herbivorous animals. We are obliged to end these citations here, free to return to them later. But, truly, the mind is struck with amazement in the presence of the immense resources offered by chemistry—the true substratum of every industry.

We now come to old rags, which are nothing but waste. Old rags, whether they have been gathered on the highway by the rag picker, properly so called, or have been collected at private houses by the bargain seeker or the broker, form two great categories: 1, the linen or cotton rags, called paper rags; and 2, the woolen rags, designed for making shoddy, after being sorted and reduced to first stuff.

Whatever be the nature of the old rags, they undergo a preliminary sorting on coming from the rag gatherer's bag or basket. After this, they are purchased by the master ragman, who occupies a higher rank in the hierarchy. After a more methodical separation of the various sorts, the master ragman sells them to the wholesale dealers, according to their specialty, for one dealer occupies himself exclusively with rags for the manufacture of paper, and another with woolen rags, while others are engaged in the business of selling both kinds.

Rags for the Manufacture of Paper.—Upon coming into the hands of the wholesale dealer, these rags are carefully classified, according to their quality, their whiteness, their color, and their cleanness. This classification comprises about ninety-five numbers, whose value varies between five and fifty-five francs per 100 kilogrammes.

For the purpose of sorting, the rags are spread out upon a table, whose top is formed of interlaced wire, in order to permit the dust to escape. They are examined piece by piece, the hems and buttons are removed by means of a knife fixed to the table, and the rags are cut into fragments. In this state they are ready to be converted into pulp. We shall not dwell longer upon this part, already described in the manufacture of paper. Let us, in a few words, summarize the economic question which we spoke of in the beginning.

The paper rag industry, which has already seen its commerce put to the proof by the constantly increasing competition of the wood pulps that enter free into France, is finding itself further menaced by the exigences of the paper manufacturers, who are demanding the imposition of an export duty of eight francs per 100 kilogrammes upon rags, which forms a combination of free trade and a somewhat advantageous but somewhat leonine protection. It is true to say that the rag merchants are earnestly opposed to an export duty on their products, which would kill their export trade, but they demand an import duty of two and one-half francs per kilogramme upon the succedaneous pulps used in the manufacture of paper, that is to say, the same pretensions, evidently more modest, but also the same error.

Will our tariff commission make its exit adroitly from this new circle of Popilius? As the Italians would say, *Chi lo sa?*

Woolen Rags.—The genesis of the woolen rag is the same as that of the paper rag, but its treatment after the sorting is much longer and more painstaking. It serves, as we have said, for manufacturing the product called shoddy, which is mixed with spine wool, cotton or silk, according to the quality of the fabrics that it is desired to obtain. The classification of woolen rags comprises more than 200 categories, the prices of which vary between 5 francs (cotton warp) and 100 francs (white sorted flannel) per 100 kilogrammes. The trade in rags of all sorts is very extensive. In Paris alone it amounts to more than fifty million francs, about 65 per cent. of which concerns woolen rags. The greater part of the latter (75 per cent.) is exported, England being the nation that uses the most. So several of our wholesale rag dealers, in order to assure their commercial relations, have branches in that country. Thus, Mr. Verdier-Dufour and Mr. Moulins, to men-

tion them only, have extensive depots at Dewsbury, in Yorkshire, which is the principal seat of the manufacture of cloths and of the reduction of rags to first stuff.

That stated, we shall speak of the operation of sorting woolen rags. In order to give as accurate an idea as possible of this to our readers, we thought that we could do no better than to visit an establishment that is a model of its kind. We were received by the head of the house, Mr. Verdier-Dufour, who facilitated our investigations with a cheerfulness for which we here thank him.

Let us say at once that independently of the sorting of rags, that amounts to 40,000 kilogrammes per day, this house does a trade in broken glass, and of kitchen bones designed for the manufacture of small bone objects, and of such bones as serve for the manufacture of glue and animal charcoal. The weight of these two latter species of waste products daily treated is not less than 60,000 kilogrammes. The persons employed number 300, of which 200 are women. The rolling stock consists of 40 wagons, and the tractive force of 36 horses. The motive force comprises a 6 h. p. gas engine, which drives a bolting machine, and a 25 h. p. Weber & Richmond horizontal engine. This latter actuates an Edison dynamo, the current of which is sent in the daytime to a receiving apparatus that works a windlass, and at night supplies 12 regulators and 60 incandescent lamps.

The rags are manipulated in two sections of a building connected by a bridge, the larger of which is four stories high. This is entered through a very high floor called a "quay," because the wagons are arranged there in order to be loaded and unloaded. This part is the store house, where are arranged, in sorts and bales, about 200 kilogrammes of rags ready for sorting. The first story is a vast hall divided into a large number of compartments 1½ meters in width by 5 meters in height, and terminating above in a sort of chimney communicating with the shops above, and the object of which we shall presently explain. Each of these compartments receives a different sort of rags ready

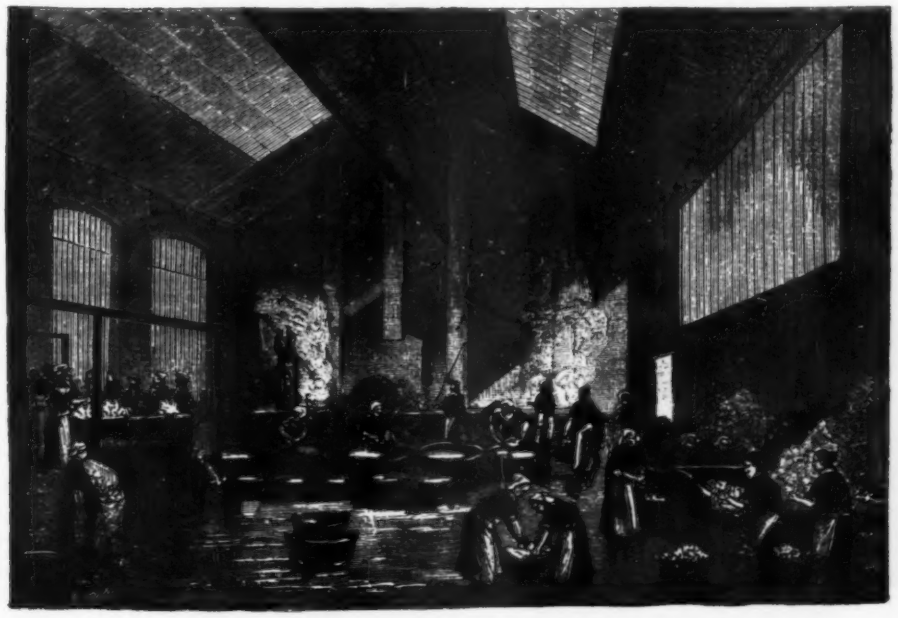


FIG. 2.—HALL FOR SORTING BROKEN GLASS.

to be packed. The second story is devoted to the classification of fine woolens (merinos and tricots); the unfulled cloths are classified in the third; and in the fourth is the shop in which new and military cloths are sorted, and which is represented in Fig. 1.

The bales of rags are hoisted to the shops by means of an electric windlass, which is shown to the left in Fig. 1. The bales having been opened, the rags are distributed in a lump to the female operatives, who are about fifty in number in the shop that we reproduce. Each operative, surrounded with several baskets, begins the sorting; putting the articles of the same nature and color together. When a basket is full she carries it to the table shown in the center of the room, and the top of which consists of a wire sieve with meshes one centimeter square. Here and there are apertures $\frac{3}{10}$ meter square. These are the orifices of the chimneys that we mentioned above.

The sorter, having placed her basket upon the table, has her work examined by one or more operatives selected from among the oldest and most skillful of the female employes. The examiner, as she is called, spreads the sorted rags upon the table, and, with surprising skill and dexterity, verifies the work, putting aside, to be handed back to the sorter, such rags as do not belong to the classification proper to them. The sorters are paid by the weight of the rags sorted, and proportionally to the density of the latter. A skillful operative can make 3½ francs a day. After her verification is finished, the examiner throws the rags into their respective compartments, through the orifices, after having shaken them in order to remove the dust.

We cross the bridge and reach the only story of the other section of the building, containing the shops in which the inferior qualities of rags are sorted. Here we find a machine driven by the gas engine already mentioned, and the object of which is to free the rags of their excess of dust. The ground floor serves as a place of storage for the bales of classified rags.

From this structure we pass to another, where we find ourselves in the presence of a truly curious spectacle; it is the shop in which broken glass is sorted, and which is shown in Fig. 2. The pieces of glass, when received, are thrown into tubs containing a boiling lixivium of potash, in which they are stirred about by women or girls provided with iron shovels. After being freed of the substances that sully it, the glass is put by shovelfuls into screens, which are shaken, by women, in troughs filled with water. The pieces of glass are then clean, and, what is important, their color can be distinguished. All the pieces that are somewhat large are reduced to small fragments by the washer, who afterward empties the contents of her screen upon tables in front of which stand the sorters, whose business is to place in a pile the pieces of similar color, since, as this glass enters into the manufacture of new glass, the presence of metallic oxides foreign to the color that it is desired to obtain would injure the casting. One experiences a painful sensation on seeing the women take by the handful these pieces of broken glass, whose size varies from a mere fragment to that of a nut. The sorted glass is put into bags and sold to glass works at the price of 8 francs per 100 kilogrammes. A woman can earn from 1 to 1½ franc per day. Bottle glass is not treated, because of its slight value (8 francs per 1,000 kilogrammes), but is the object of a special trade, which is pursued by itinerants, who sell it to manufacturers of sand paper.—*La Nature.*

STREET CLEANING IN PARIS.

ONE of the officers of the Bureau des Travaux de la Voie Publique, of Paris, has contributed to the New York *Herald* an account of the methods of street cleaning employed in that city, of which we make the following abstract, although repeating some matter already published in this journal, as affording an interesting comparison with the methods employed in the leading cities of America. While the figures may not be absolutely correct, the explanation of the work is especially interesting in view of the widespread interest in the subject.

In Paris, the entire city is thoroughly washed down with water every five or six days during dry weather and more often during a wet season. This washing, which is no mere superficial work, but a thorough scrubbing and cleansing of the streets, as carefully done as the washing of the interior of a house would be, takes place early in the morning, beginning between 3 and 5 o'clock, according to the season of the year.

The process is generally as follows: In each block there are several water mains, so that wherever needed along the street, water can be played freely from a large hose which is run along on rollers. The roadman in charge of the hose comes first in the party. The nozzle is coarse and the power of the water great enough to dislodge from the pavement any dirt that may have become incrusted.

What the hose fails to accomplish is speedily completed by those who come next with the hardest bristle brushes. The cleaning gang follow the hose in two diverging lines like an arrow head, and pass the mud along until it reaches the gutter. Then they form in line along the gutter. In each block there is a street inlet, beside which one of the workmen stands and shovels down the mud as it is passed along to him.

Where the pavements are of wood and asphalt, as is the case in nearly all the leading boulevards and streets, a stiff plate of rubber held in a wood frame, and forming a kind of flexible hoe, is largely used in place of the broom, and is found to be highly effective. The machine sweepers are also largely used, but not on level pavements. They generally clean about 6,000 sq. yds. an hour, while a laborer is expected to do about one-tenth as much.

The sweeping is carried out by the city each morning and during the day. Formerly the morning sweeping was done by the householders, but by a law of 1873 the inhabitants gladly relieved themselves of the task by paying a lump sum to the city, which has since taken charge of it.

The total surface which is swept twice a day is approximately 18,600,000 sq. yds. (?) and the annual cost of the work is 6 cts. per sq. yd.

The sweepers are enrolled in brigades, of which there are 149, each composed of a chief, sub-chief and 35 laborers, both men and women, the majority of whom work in the morning only.

For more than the half day are retained only those having the title of roadmen, whose duty it is to see that all the work is properly carried out, such as supplementary sweeping and flushing of the gutters. This is done by unlocking the small cocks, of which there is one on each side of every block, and thus thoroughly cleansing the gutters with pure water. This flushing is manipulated by the roadman so as to cause the water to flow first in one direction and then in the other by making a small dam of sack cloth in the gutter. The flushing continues throughout the day, carrying away the dust in dry weather and the mud when it rains. The water that is used comes from the Seine River.

The regular laborers begin work at 4 A. M. throughout the year and their day closes at 4 P. M. Those who work only on half day time stop at 11 A. M. The organized service consists of about 3,200 persons, the majority of whom are employed in the center of the city, where the traffic is greatest and the markets are located.

The number of auxiliary laborers varies greatly, depending upon the condition of the weather. The sweepers are paid as follows: Able bodied men, 6¼, 6½ and 7½ cts. an hour; old men, women and children, 5, 5½ and 6 cts. an hour. The monthly salary of the roadmen is $35, and $24 for chiefs and $21 for subordinates.

Watering commences, except under exceptional circumstances, on March 15 on the macadam and April 15 on the paved streets, and terminates September 30 on the paved and October 15 on the macadam streets.

Originally all the public roads were watered with carts, costing 0·0002 ct. per sq. yd. for macadam and 0·0001 ct. for paved streets. For several years past, however, the principal thoroughfares have been watered with the hose.

This hose is composed of a number of iron tubes, joined together with strong waterproof canvas joints and mounted on wheels for greater ease in moving. The hose is screwed to a cock which lies beneath the level of the sidewalk. By this system the total cost of watering, including labor, apparatus and water, amounts to 0·000109 ct. per sq. yd. The surface now tended in this manner embraces about 3,770,000 sq. yds.

The watering cart on paved surfaces can cover about 24,000 sq. yds. daily, whereas on macadam roads the average duty is only half as much.

At present there are about 370 horse and 130 hand sprinkling carts. These belong to the city, while the horses are furnished by the contractors at $68 a month, including the pay of the driver. The surfaces watered by the carts are as follows: Paved streets, 5,240,000 sq. yds.; macadam streets, 7,740,000 sq. yds.; asphalt streets, 310,000 sq. yds.; wood pavements, 209,000 sq. yds.; side alleys of sand, 12,000 sq. yds.; total 6,555,000 sq. yds.

All the sidewalks of Paris, be they of granite, asphalt or mosaic, are submitted to the same kind of cleaning. Hand work is entirely used, owing to the numerous kiosks, which prevent machine cleaning. In dry weather a simple sweeping with a birch broom is sufficient, this implement having proved the best instrument to clean corners and small spaces. In wet or foggy weather, or during a very light rain, when the sidewalks are apt to become muddy, if the mud be hard it is removed by a scraper, but if soft the usual way is to add more water and rub with the rubber scraper before mentioned.

In the case of the smaller pavements, the washing is done as follows: The mouth of the main is opened, allowing the water to flow down the gutter, from which it is taken in a scoop with a long handle and thrown over the sidewalk. At the same time another workman goes over the pavement with a brush broom and then cleans it off with the rubber scraper. When it rains the scraper alone is sufficient. Paper and other refuse are carefully removed at all times. The cost, according to the budget of 1889, for the maintenance of paved streets amounted to about $956,900 over a surface of about 7,570,000 sq. yds., or 12·7 cts. per sq. yd. This includes both cleaning and repairing.

There were about 1,792,000 sq. yds. of stone pavement, the maintenance of which cost $650,700, or 35·3 cts. per sq. yd., and 534,000 sq. yds. of wooden pavement, calling for 36·2 cts. per sq. yd. for maintenance on the most frequented streets. The cost of keeping the asphalt streets in condition was about 33·3 cts. per sq. yd. With wood pavement it is absolutely necessary to have subways for wires and pipes, as the surface should never be disturbed. The pavement of this kind laid in Paris has given very good results, but great care was used in preparing the Portland concrete foundations and in selecting the wooden blocks.

In dry weather the rules for washing the streets are as follows: On streets paved with stone, about once in 3 days; on macadam, once in 3 days; on asphalt, once in 2 days; on wood, once every day. As a general rule, these washings are performed between 4 and 8 o'clock A. M.

During the day, as soon as the sweeping and washing is over, the refuse is emptied into the drains or carted away. During rainy weather the sweeping is done two or three times, and during the frosty season a second machine sweeping takes place in the afternoon. Each sweeping is followed by a thorough cleaning of the gutters.

The birch broom is the most effective instrument for the latter use. The mains are quite low, almost on a level with the gutter, so that when the water rushes out, the roadman, by means of a piece of rough sackcloth can form a little dam to direct the current in any direction he pleases.

Another carefully managed and important detail is the sprinkling of sand, more especially on wood and asphalt surfaces. There is no rule for this work, as it depends largely on atmospheric conditions. The roadmen have orders to use sand as often as is necessary, and are accountable for the faithful performance of the work.

The schedule of the day's duties is as follows:

4 to 6:30 A. M.—Brushing and washing of streets and sidewalks; sanding, to insure a good footing for the horses; disinfection and washing of soiled surfaces.

6:30 to 8:30 A. M.—Removal of house refuse.

8:30 to 11 A. M.—Cleaning of street track; washing gutters; watering.

11 A. M. to 1 P. M.—Meal time of the roadmen. The meal is advanced to 10 or delayed until noon if necessary from atmospheric conditions, and is sometimes reduced to one hour. During extremely hot weather the watering service continues without interruption. The men are then divided into two sections, one working while the other rests.

1 to 4 P. M.—Machine sweeping, if necessary; watering; cleaning; sweeping sidewalks; washing benches.

7 to 9 P. M.—During the five winter months sanding asphalt and wood pavements, which is considered as extra work.

The way in which ice and snow are handled in Paris is very perfect. It is an absolute rule that in time of snow the active workers, whatever be their duties under ordinary circumstances, are to be employed in the snow service. Depots are organized and an intelligent roadman placed at the head of each, and here the supplies of sand and salt are established. All the streets are classed according to the urgency of the work required in them, the main centers of traffic, the principal omnibus and horse car routes and similar thoroughfares being cleared first.

In broad streets the snow has to be heaped in two banks, and a central way five to seven yards wide is first prepared. In the small, narrow streets with heavy traffic the snow is entirely cleared away, and in unimportant streets a single bank is formed and the snow is left to thaw and melt away.

The best cleaner for light snows is the machine sweeper with steel brushes. In 1880 a sort of plow mounted on runners was introduced. They were triangular in shape, 11½ ft. broad at the rear and with sides diverging at an angle of 50°. The two blades of sheet iron met in an iron point or spur. They were not very successful, and the 88 now belonging to the department are rarely used.

Salt was first used on a large scale in Paris in 1880. It is carried about in small carts drawn by three or four men. One man sits in the cart and throws the salt with a large shovel all over the road, where it thaws the snow into a slush which will rarely freeze. Then the rubber scrapers are brought into requisition and the whole is driven down the gutters into the sewers. The means of sprinkling the salt are so far rather primitive, but several new ideas are under discussion.

The snow is disposed of in two ways. One is to dump it into the Seine through special culverts opened during the winter season; and the second, and possibly more general way, is to dump it into the sewers. When the latter method is employed, the sewer tenders are put on special duty to see that no stoppage occurs, and water is freely used to flush the masses along.

During the period of snows the Compagnie Générale des Omnibus is required by its charter to place 52 horse carts at the disposal of the city engineers and to transport at the beginning of winter 4,000 cubic meters of sand to any point designated by the engineers.

When the snow falls during the day, without waiting for the fall to cease there is a general turnout of the roadmen and workmen from the various organized centers before mentioned, equipped with brooms, shovels and scrapers. They immediately begin shoveling the snow back from the streets to the sides and brush off the sidewalks where this work devolves upon the town, as in front of public buildings, vacant lands, bridges and quays. The residents do the same on the part that concerns them, sometimes requiring to be notified to do so. Effort is made to keep up the circulation on the sidewalks and to keep passage ways of sufficient size for vehicles. Where the snow is too deep for manual labor the machine sweepers are put to work, and the workmen complete the clearing.

If, finally, the morning brings a surprise in the way of a considerable fall, the plows are taken out, and an attempt made to open zones from 5 to 8 yds. wide. Then the machines follow. If these combined efforts fail, owing to the snow being hardened by traffic over it, the best remedy is found to be in scattering a thick layer of sand, or making use of salt, which will enable the sand to work into the snow.

CAMPHOR INDUSTRY IN FLORIDA.

THE possibilities for the establishment of a paying industry in the line of camphor production in the Southern States, notably Florida, are very promising. Last year attention was called to the fact that the camphor tree can be profitably grown in the South, and at the recent meeting of the A. P. A. further statements to this effect were made.

Messrs. A. J. Beach & Son for some time have been experimenting at Palatka, Fla., and from them is gathered some interesting information.

For the growth of the camphor tree the preparation of the soil is very easy and simple, the tree growing with very little care after first starting. All timber should be cut and piled, not burned, and left to rot on the ground. The soil is thoroughly grubbed where the tree is to stand. The tree is planted and carefully staked to prevent the wind from swaying it when it is first set out. For three or four years the ground should be carefully worked around the trees and kept clean, the growth of timber being kept down and grubbed out, but after this time the tree will take care of itself.

The first trimming of the camphor tree is to a sufficient height for the body of the tree; after that thin out the top and shear off the outside of the top, as the young wood is the most productive of camphor.

The extraction of the gum is very simple. There is used for the purpose a still consisting of an iron pot holding about five pailfuls, and provided with a wooden cover into which is fitted a one inch pipe leading to the condenser. The top of the kettle and cover are plastered with clay to prevent the escape of camphor vapor during the process. From the kettle the pipe turns and runs horizontally into a wooden trough about eight feet long, and then turns down and discharges into a tin can which catches any water condensing in the pipe. To charge the still the cover is removed from the kettle, which is then filled with small limbs and leaves of the camphor tree. A few quarts of water are then added to keep the leaves from burning (they burn very easily). The cover is then fitted on securely and under the kettle is placed a very small fire, and the pipe connected with the pipe in the trough, which is kept full of cold water supplied through a hose. As soon as the water produces the least steam, the camphor volatilizes, passing over very rapidly. As it leaves the still it follows along until it comes in contact with the cold portion of the condenser, where it condenses and sticks to the inside of the pipe in the shape of fine crude camphor. The condenser pipe is slanted a little, so that any water condensed may be delivered into the can. Long before the water reaches boiling point the camphor is nearly all volatilized, but the water is allowed to form a little steam, that all the camphor vapor may be driven into the condenser. Every portion of the still must be securely sealed to prevent the escape of the vapor.

To remove the gum from the condenser pipe the pipe is removed from the trough, stood upon end, and struck sharply with a hammer, when the gum will rattle out of the low r end.

Messrs. Beach & Son have carried on the camphor industry in a very small way as yet. They have only a few trees, which are too small to cut much from. Nearly all the wood for experimenting has been obtained from other places. All the trees, except what were imported, were provided by the Department of Agriculture several years since, and consequently are now quite large. Other experiments are to be undertaken as fast as the wood can be procured. The yield, as nearly as can be estimated by weighing limbs and leaves, is almost 1 to 25, that is 1 pound of crude gum to 25 pounds of limbs and leaves.—*Pharmaceutical Era.*

PHOTOGRAPHY ON A BLACK GROUND.

IT is now very long ago that our readers learned to know, through the qualified pen of Mr. A. Londe, always on the alert for photographic novelties, the varied effects that may be obtained, either from an artistic or a simply amusing point of view, by the use of what is called the Russian background. But more than one amateur assuredly will have met with the difficulty of obtaining (aside from a special installation) the necessary perfection in backgrounds or screens, especially since the fashion has turned to the bust portrait degraded upon black. So our readers will doubtless thank him who, in these very pages, was one of the first to recommend the magnesium flash light, for pointing out a process within the reach of every one for executing the most extraordinary combinations that the imagination could suggest, without complicated accessories and by a simple, judicious use of artificial light.

In the first place, what is blacker than a window open at night on the darkness? The flash light per-

THE AUTHOR PHOTOGRAPHING HIMSELF WHILE JUGGLING WITH HIS HEAD.

mits of making any exposure whatever in front of it, and the black of the background will certainly rival that of the first studios of the Boulevard.

It will be said that this is not a very practical method in cold-in-the-head weather! Let us close the window, then, without insisting, and let us open the door. One has always, even in the winter of 1891, a door for opening in his house. A little back of the embrasure, let us place the model face to the apparatus, and then let us flash the light at the side, as he sits for the artistic effect. A deep shadow projecting itself behind the sitter will furnish us with the desired black ground. Black, I say, whatever be the real color of the said ground, and whatever be the lights burning in one or the other room. Black, that is to say, inactinic for gelatino-bromide, although visible to our eyes.

For there is a prejudice against which I cannot too much protest; it is useless, even in order to operate *upon* black, to condemn one's self to operate *in* black. The magnesium light alone counts from an actinic standpoint, and all the light furnished by the candles, kerosene lamps, gas, or even incandescent lamps that may exist in a room would require, in order to give however slight an impression of the surrounding objects upon a photographic plate, so long an exposure, so great a fraction of an hour, that it may be absolutely disregarded during the largest openings of the objective in the kind of operation that we are to occupy ourselves with. Even when there are directly in the field one or more of those sources of light with which we are content for domestic purposes, but which, as white as they appear to us, are nevertheless really yellow or red and contain few violet rays, what will happen? They will *pose* simply with their surrounding, the image of which is so slightly veiled, even for the nearest objects, that it is a chance if we find a trace of it where these objects, through some polished surface, have performed the function of reflectors and not of simple diffusers. As for the image of the flame, that will be perfectly defined, with all of its details. At the worst, if the exposure has been of an exaggerated length, it will be found surrounded on the negative with an aureola or halo due solely to the reflecting action of the glass employed as a support, and which has nothing in common with what is called the veil, any more than it has with that other accident that occurs with a still further prolonged exposure, and which consists in the reversal of the image, become positive upon the negative.

It is therefore useless (and I repeat it earnestly, on account of the contrary belief of so many professionals) to make night in order to photograph night, and to believe that one is obliged, for example, to represent a drawing room without chandelier, and a dinner without candles. To return to what occupies us, leaving all undisturbedly lighted, let us be anxious only lest our background shall receive at second hand too great a number of magnesium rays diffused through the part of the room where we cannot entirely prevent the reflection of the flash from penetrating. For that, the utilization of the leaf of the door, open on the side of the sitter opposite the flash, will have the double advantage of arresting, on the passage, the greater portion of the rays that tend to enter the dark room, and of sending them back to the side of the sitter, who, without that, would run the risk of being too deeply shaded. It is possible, even, by placing the sitter and light geometrically in a right line with the edges of the jamb and the open leaf to prevent any direct ray from entering the room. After this, the darkness of it will be certainly comparable to that employed by Mr. Marey for his remarkable photochronographic studies on locomotion, that is to say, the most perfect that has been realized up to the present.

Since now, without trouble and expense, we are here possessors of an ideal background, nothing remains but to utilize it in order to derive from it all that it is capable of giving us.

To commence, would you like to try one of those simple, degraded blacks which so well bring out light clothing? It will suffice, after making the exposure as indicated above, to operate according to the classic method, by putting into the camera a shutter containing an aperture which allows of the passage of only that part of the image that it is desired shall reach the plate.

Does the operation seem to be somewhat delicate, and does the regulation seem tedious by the light of the candles? Or does the apparatus refuse to allow of the introduction of the shutter? Here is how it will always be possible and easy to operate: Take some sort of a dark fabric, and, throwing it over the back of two chairs, a slight distance apart, in front of the sitter, regulate the curvature of the falling fold in such a way as to conceal the sitter up to the shoulders from your eye, placed against the objective. Then flash the light in front of this screen in such a way that the face seen from the apparatus, receiving no direct ray, shall remain black for the objective. There will be thus obtained upon the plate a bust entirely detached from a dark ground and degraded toward the bottom, where the edge of the veil will have become so much the lighter and softer in proportion as it will have been less perfectly in focus, that is to say, nearer the apparatus.

There is no need of adding that on reversing the process, that is to say, on substituting white for black, light for shadow, and a sheet (or, better, on account of the folds, indented cardboard) for the drapery, it is possible to obtain directly upon the negative the ordinary degraded white that it takes so much trouble to obtain in printing photograph by photograph. So it is to be wagered that, having got a liking for it through an easy success, you would not wish to stop there, but would feel inclined to apply the method to the realization of some of those tempting trifles to which attention has so many times been called in this journal.

Take, for example, the charming photo bust of Mr. Gravet. Who has not, after making a negative, been confronted by the too sensible difference between the blacks of the profiling and the accessory draperies? Now, by the use of our background, the risk would be much lessened; but to succeed almost to a certainty, one has only to proceed as follows. A first exposure on a shadow ground is made with the pedestal, the position of which must be accurately marked on the ground glass. Then a second exposure of the model in half-length degraded upon black, so regulated that the soft lights of the bust on the ground glass are lost over the pedestal—an operation that is reduced to a simple control if advantage is taken of the fact that, this time, there is nothing to prevent the pedestal from being left in place in front of the model, since it must, in definitive, be hidden by the veil.

Upon the negative we will find the image of the pedestal separated from the bust by a degraded zone, a few lines of which, through a broad after touch, it will suffice to arrest and make more marked, in order to obtain a result which will not only have suppressed the faults of the profile, but also and especially its stiffness, etc., in the cut-out parts of the living bust.

Remark that it would have been perfectly allowable for us at the first exposure (that of the pedestal) to take at the same time, around the pedestal, any group whatever of persons or objects filling all the parts of the black field that it was not necessary to reserve for the bust itself. And then, instead of the effect of a solitary and somewhat conventional bust, the trick of which is easily divined, we obtain family pictures which are very puzzling through the presence, in a second living edition, of the person all entire from head to foot, a fraction of which, statufied, attracts in the first place one's whole attention.

The system of double exposures, thus understood, may, moreover, with a little additional complication, lead us to applications in other ways, original without being much more difficult, by combining changes of distance of the apparatus between each of the operations. Let us suppose, for example, that, having placed the apparatus so near the model that the focusing throws out of the plate the frame of the door or window whose opening serves us as a black background, we have taken the image of a large head, the neck of which occupies on the ground glass a position marked in advance with pieces of gummed paper.

There is nothing to prevent us from afterward moving our apparatus back to the maximum distance where the reduced image No. 2 of the door will embrace on the ground glass the large image. No. 1, of the head. Let us then place across or in front of the door a fully set table, with a large center piece so arranged that its edge shall coincide, in definitive, with the neck of the decapitated person. By way of parsley (but rather to secure adjustment and suppress the line of junction of the two images, than to improve the aspect of the service), let us place in the bowl a crum-

pied white napkin, in a slightly emergent puff. It will only remain for us to place around this new sort of a dish a few astonished guests, or among them, of course in the front row, the possessor of this so well mounted head; and provided that we have well regulated things and avoided superpositions, we shall obtain a picture of photo-auto-megalanthropophagy, which will not fail to puzzle the cleverest persons if they are not acquainted with the artifice.

It is useless to point out all the variants of which this idea is susceptible; the man with a big head, the gigantic hunter, Saint Denis carrying his head, will be but a play. But one difficulty will present itself if it be desired to operate in the opposite manner, that is to say, to give the principal details of the picture extremely reduced dimensions and not more exaggerated ones, to represent, for example, a large man in contemplation before his statuette, or a small man looking at himself grow, or a cook making a *sauté* of heads over a stove, a juggler playing with a ball, etc. It will be seen that it is easy to vary the subjects.

It becomes, then, almost impossible, on moving the apparatus back in order to obtain the small image, to eliminate the neighboring objects from the field, especially the door frame, and it was only after uselessly attempting to get around the obstacle by all the means known, that, having decided to submit the question to calculation, I was fortunate enough to deduce therefrom an absolutely general method, including the preceding particular case, and permitting of responding, with security, to the most fanciful ideas.—*La Nature.*

A MONSTER MACHINE-CUT SPUR GEAR.

THE cut of the gear shown herewith represents a very large machine-cut spur gear, made by the Walker Manufacturing Co., of Cleveland, which was used, in connection with a steel pinion made by the same concern, on large pumping engines for removing water from one of the South Africa diamond mines. The dimensions of this gear were as follows: 192 teeth, 30 ft. 6 66" pitch diameter, 30" face, 6" pitch, bore 27"; diameter of hub 9 ft. 2"; weight of hub being 15 tons, and total weight of gear 66¾ tons.

Some conception of the exactness required in the formation of this large wheel may be realized when it is known that the owners, in order to provide for a possible breakage, which is most improbable, ordered one segment and one arm additional, the requirements of which were that these parts might fill any position in the wheel. The wheel was fitted up most carefully and presents a fine piece of machinery, as may be judged from the illustration.

This gear, with the steel pinion, was the only part of the massive pumping machinery which was made in this country, the balance of work being contracted for in England. In reply to an inquiry as to why the gears had been singled out for manufacture at a different point than the rest of the machinery, the engineer of the company replied that he thought they could rely on getting a superior class of iron in America, and he knew they could secure as perfect work.—*Iron Trade Review.*

A MONSTER MACHINE-CUT SPUR GEAR.

THE NEW GAS, CHLOROFLUORIDE OF PHOSPHORUS.

As briefly announced in the report of the proceedings of the French Academy of Sciences, a note upon a new gaseous compound, containing phosphorus, fluorine, and chlorine, has just been presented by M. Moissan, on behalf of M Poulenc. During the course of his work upon the fluorides of phosphorus, M. Moissan observed that, when phosphorus trifluoride was brought in contact with chlorine, the green color of the latter at once disappeared, and there appeared to be formed a new and colorless gas. The gas thus formed has been prepared in considerable quantity by M. Poulenc, and its properties investigated. It appears to be directly formed by addition, according to the simple equation—

$$PF_3 + Cl_2 = PF_3Cl_2;$$

for the trifluoride of phosphorus and chlorine are found to react in equal volumes, and the combination is attended by a contraction of one-half. The new gas may therefore be considered as phosphorus chlorofluoride, PCl_3F_2, the chlorine derivative of phosphoryl and thiophosphoryl fluoride, POF_3 and PSF_3.

The most convenient mode of preparation is described as follows: Two flasks of equal capacity (about 500 c.c.) are taken, and filled respectively with phosphorus trifluoride and chlorine. They are connected together by a bent tube passing through the stoppers, and the flask containing the phosphorus trifluoride is further connected with a reservoir of mercury in such a manner that a gentle pressure may be placed upon the trifluoride, so as to gradually displace it over into the chlorine. The two flasks being of equal capacity, it is evident that, when the whole of the trifluoride has thus been transferred, the reaction is completed, the green color of the contents of the other flask disappears, and the remaining gas is almost pure chlorofluoride. After allowing to stand a few days in contact with the mercury, in order to remove the last traces of chlorine, the gas is ready for examination.

Phosphorus chlorofluoride is a colorless incombustible gas, possessing a powerfully irritating odor. It is instantly absorbed and decomposed by water and by solutions of alkaline or alkaline earthy hydrates. A determination of its vapor density gave the number 5·40, sufficiently near the theoretical density of a substance PCl_3F_2 (5·46). It is comparatively easily liquefied, a temperature of —8° C. being sufficient at ordinary pressures. It is dissociated at a temperature of 250° C. into gaseous pentafluoride and solid pentachloride of phosphorus. The induction spark effects the same decomposition.

Sulphur reacts with phosphorus chlorofluoride in a most interesting manner. The reaction commences about the melting point of sulphur, 115° C., and the products are chloride of sulphur and gaseous thiophosphoryl fluoride, PSF_3. And here a most emphatic protest must be made against the manner in which many French chemists persistently ignore the work of the chemists of other countries. Thiophosphoryl fluoride, PSF_3, was discovered and prepared three years ago in the Research Laboratory of the Royal College of Science, South Kensington, by Prof. Thorpe and Mr. J. W. Rodger; and a detailed account, illustrated by experiments, of the mode of preparation and properties of this remarkable gas was laid before the Chemical Society and published in their journal.* And yet, in the memoir just presented by M. Moissan, we find this compound, a description of which long ago found its way into the abstracts or referate of most foreign journals, described as "un nouveau composé gaseux." Indeed, a considerable amount of unnecessary trouble appears to have been taken in order to ascertain the composition of this "new gas"—trouble which, as the compound is so readily recognizable by its extraordinary properties, might have been saved, if the author had taken the pains to look up the literature of the subject. It is high time that French chemists should look to their "prestige" in this respect, for, unfortunately, the present is by no means the only case which has within the last few months come before the notice of the writer of this note, in which compounds fully described and worked out by English chemists have been rediscovered and described as new by French authors.

When phosphorus chlorofluoride is passed over free phosphorus heated to 120°, it is decomposed with formation of phosphorus trifluoride, which passes away as gas, and phosphorus trichloride, which condenses in liquid drops. Metallic sodium, when slightly heated, appears to absorb the chlorofluoride entirely, while magnesium, aluminum, iron, nickel, lead, and tin, when heated to about 180°, attack the gas, with formation of anhydrous chlorides and liberation of phosphorus trifluoride. Mercury attacks it very slowly at the ordinary temperature, but very rapidly at 180°, with formation likewise of a chloride of the metal and gaseous trifluoride of phosphorus. Hence, when purifying the gas from the last traces of chlorine, the mercury should not be agitated, but allowed to remain at rest, as agitation brings about a perceptible amount of decomposition.

Water reacts in two stages with phosphorus chlorofluoride. When a little aqueous vapor is admitted into the vessel inclosing the gas, phosphoryl fluoride and hydrochloric acid are formed in accordance with the equation—

$$PCl_3F_2 + H_2O = POF_3 + 2HCl.$$

When passed into water, however, the gas is completely decomposed into phosphoric, hydrochloric, and hydrofluoric acids—

$$PCl_3F_2 + 4H_2O = H_3PO_4 + 3HCl + 3HF.$$

Ammonia gas reacts at the ordinary temperature with production of a white solid compound, readily soluble in water, which appears to be fluophosphamide, $PF_3(NH_2)_2$.

$$PCl_3F_2 + 4NH_3 = PF_3(NH_2)_2 + 2NH_4Cl.$$

Phosphorus chlorofluoride is absorbed by absolute alcohol with production of a compound possessing a penetrating odor, and which burns with a bright flame bordered with green, and leaves a white residue of phosphoric acid. The nature of this compound has not yet been fully ascertained.

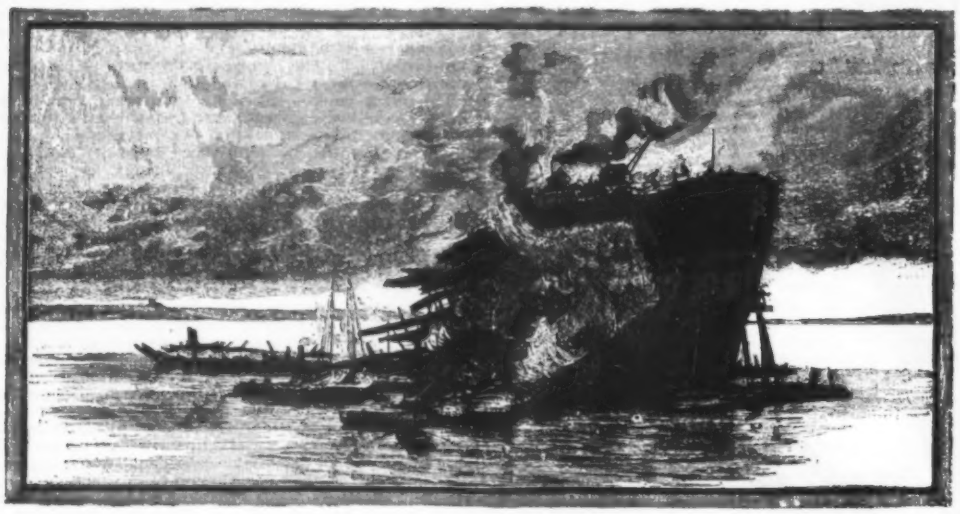
These properties of phosphorus chlorofluoride indicate that the gas is much less stable than the penta-

* Jour. Chem. Soc. Trans., 1889, vol. lv., p. 306.

fluoride, and that the two atoms of chlorine possess a mobility which renders their removal a matter of considerable ease.—*A. E. Tutton, Nature.*

THE LAST OF THE GREAT EASTERN.

AFTER thirty years' vain struggle against an adverse destiny, this leviathan steamship was beached on the shores of the Mersey, in 1888, to be broken up for old iron. One of our engravings shows the great vessel as she appeared when moving to her last berth. The Great Eastern was planned by M. Brunel & Son, and built by Mr. Scott Russell, to accomplish the voyage to the East, round the Cape, without having to stop by the way for coal, and was originally intended to take some 3,000 first, second, and third class passengers, and a large cargo. Her length was 692 feet, her breadth



THE LAST OF THE GREAT EASTERN.

83 feet, and the depth of her hold was 24 feet, and her registered tonnage 18,914 tons. She was fitted with both paddle and screw engines, carried five funnels, each 100 feet high, and had a coal bunker space of 10,000 tons. She was built at Millwall, and great difficulty was experienced in the launch, which occupied three months, and cost $300,000. The entire original cost of the ship is stated to have been two and a half millions of dollars.

In 1859 the mammoth steamship started on her first trip to the United States, but had to put back through the explosion of a steam pipe, by which a number of persons were killed and injured. Next year she reached New York, and made several trips across the Atlantic, but the receipts were unequal to the enormous expenses. In 1861 she was sold for a comparatively small sum, and her new owners spent a large sum in repairs, and she was utilized as a troop ship, to take the Guards to Canada, but it was not until 1865 that her true vocation was considered to have been found, namely, to lay a telegraph cable between England and America. In this work she was occupied for a few years, an attempt being made in 1867 to utilize her as a passenger ship between New York and Havre during the Paris exhibition; but when there were no more cables to lay she was relegated to idleness and Sheerness, where cockney "trippers" were admitted to view her interior at a shilling a head. In 1886 the vessel was taken over by a syndicate, and stationed in the Mersey as a species of People's Palace of Amusement, being subsequently transferred to Dublin. After a brief visit to the Clyde, the Great Eastern was, in 1888, sent on her last voyage to the Mersey, where she was beached near New Ferry, on the Cheshire shore, to be eventually handed over to the dismantling hammer. Even to the last her ill fortune seemed to attend her, as during her journey from the Clyde she encountered a gale, during which the tug was obliged to cast her loose, while her own engines being stopped for a short time, the great vessel became unmanageable, and for hours rolled about at the mercy of the wind and waves. On the weather moderating, however, she was again taken in charge, and finally towed by the tug Stormcock to her last berth. She was sold to the old iron dealers in 1888 for $100,000, and since that time a large force of men has been engaged in knocking her to her pieces. The last of the Great Eastern is shown in our cut, and in a short time longer nothing of this wonderful vessel will remain of which to make a picture.

JUGGLERY.*

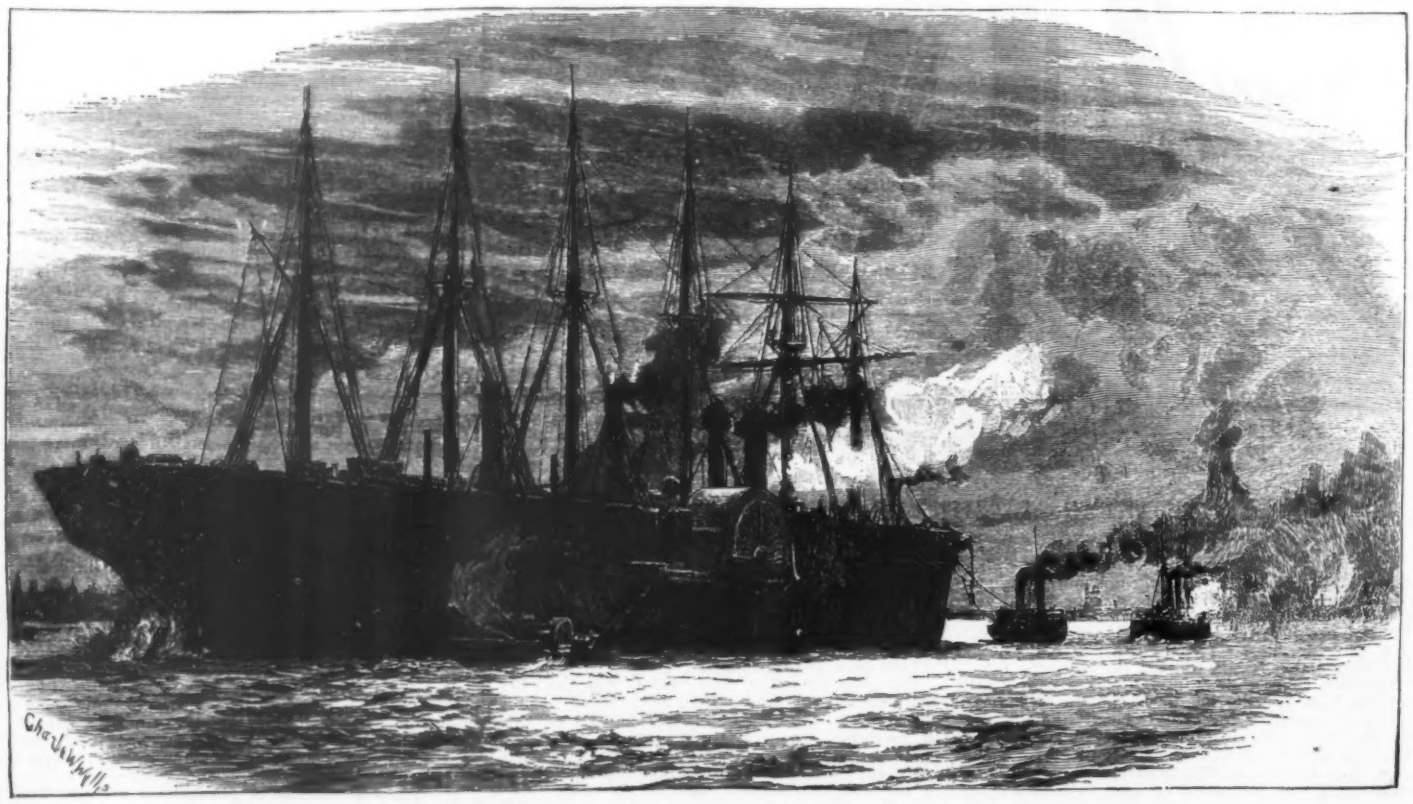
RECENTLY I met with a certain observation, the source of which, to my regret, I failed to note. I therefore take the opportunity of appealing to my readers for their kind help in identifying the passage or quotation in question, because it has a scientific bearing of a very obvious nature. The observation was as follows: A writer, in speaking of the fallacies of the senses, described the Hindoo juggler's trick of causing a small plant to grow out of a flower pot in which, a few moments before, the conjurer had placed some seeds. The pot is covered over or concealed by a blanket, and when the covering is withdrawn the apparently marvelous and instantaneous growth of the seed into a perfect plant is witnessed. Now, the writer in question goes on to state that an amateur photographer had taken a "snap shot" at the conjuror and his performance, and when the negative was developed no plant could be seen growing in the pot at all. The inference is that the spectators only fancied they saw a plant, and that the success of the trick is due to the juggler making his audience believe they see what does not really exist. In plain language, he is supposed to hypnotize the spectators, and the illusion is to be regarded not as due to his dexterity, but to his power of making the spectators believe they see what he wishes them to behold.

Assuming the incident with the camera to be true and of good report, how is the omission of the flower in the pot to be accounted for? If a photograph of the scene had been taken at all, it must necessarily have included all the details within range of the lens, and, as Boucicault makes one of his characters in "The Octoroon" say, "The apparatus doesn't lie." I do not pretend to criticise the statement at all. I am merely anxious to know if any of my readers interested in psychical matters can confer a favor by referring me to the original source of the story. My own recollection is that I casually met with the reference in an American magazine, which I glanced at while waiting for a friend. The name of the magazine and its date (which must be recent, I fancy) have both escaped my recollection.

After thinking over the above incident, one is inclined to be somewhat skeptical of the story as I have related it—although my version, I admit, may not be absolutely correct. A perusal of a paper by Chevalier Hermann, the conjurer, confirms me in my skepticism. He tells us that when he visited India he could find no foundation in actual fact for the marvelous stories of Hindoo jugglery, including the fact of "youths tossing balls of twine in the air and climbing up on them out of sight." What Herr Hermann did see in India, he tells us, he could have imitated "with little preparation," and that he "would not presume to introduce them upon the stage." This is a decided blow to the reputation of our Indian friends, and after this assertion the tales of fakirs being buried for six weeks, and recovering thereafter, may reasonably be doubted also, although I shall feel interested in hearing from any of my Indian readers accounts of what they have actually seen in the way of startling magic. It will be interesting if I quote what Hermann has to say of the flower pot trick, which the unknown psychologist has tried to explain on the basis that the conjurer causes his audience to see what does not exist—a startling enough theory, by the way, since it supposes that all sorts and conditions of men looking on could be simultaneously hypnotized.

In Bombay a troupe of jugglers appeared in front of the hotel in which Herr Hermann was staying. After a short address, an empty flower pot was produced. This was filled with earth, which was moistened with water, and into the pot a few mango seeds were dropped. A large piece of cloth was used to cover the pot, which rested upon a tripod of bamboo sticks. Then followed an address to the audience, and the operator walked slowly round the covered pot, "dexterously allowing his robes to envelop it at each turn," while the other members of the troupe chanted a kind of incantation. After some three minutes occupied in this performance, the incantation ceased, the cloth was removed, and in it was seen growing a mango tree about three feet in height, the plant having apparently grown after the planting of the seed. This is a bare description of what the Western conjurer saw his Eastern rivals perform, and it sounds very wonderful, no doubt. Hermann's explanation of the trick, however, causes us to repeat the hackneyed expression that "it is not at all startling when you know how it's done." What the Hindoo wizard did was to remove the pot from beneath the cloth—a dexterous proceeding enough, but not a whit more wonderful or clever than things we see done at the Egyptian Hall or at other entertainments of like nature—and to substitute the growing mango, which he carried concealed under his robe. "This," adds Hermann, "he did rather clumsily,

* Dr. Andrew Wilson, in the *Illustrated News of the World.*



THE GREAT EASTERN MOVING TO HER LAST BERTH.

while he let the robe rest, as if by accident, over the covered flower pot previously displayed."

This recital is interesting scientifically, because, as I have said, we hear so much about Indian jugglery and esoteric mysteries, which no science is supposed to be capable of explaining, that one may find some justification for a continued display of skepticism when still more mysterious feats are gravely detailed. I find that the facts about Indian magic and mystery set forth in books in grave, circumstantial array do not always coincide with what actually occurs; hence my appeal to Indian readers of these lines for accounts of things they may have seen in the way of live burials and resuscitations (if such things are still in vogue) and like phenomena. I referred, when I began these jottings, to the idea that the explanation of a trick was to be found in the delusion of the spectator's senses; and this reminds me of a very interesting case which certainly proves to us how a dominant idea may be impressed on the minds not of a few spectators but of thousands, with an utterly futile result when all is said and done. When the Crystal Palace took fire, many years ago, efforts were made to rescue the animals from the menagerie, which was lodged in the burning part. As the fire progressed, a large monkey was seen by the spectators to appear on the roof and to hold on to some pinnacle or other, apparently writhing in terror at its impending incineration. Desperate attempts to reach the unfortunate animal were made. The crowd was breathless with anxiety. Every movement of the rescuers was watched with agonizing interest. At last the ape was reached, and was found to be—a piece of canvas, which had apparently been detached from the building, and which, clinging to some post or pole, had impressed the crowd, by its flapping, with the idea that it was a big monkey writhing with fear and agony. This, I believe, is a well founded fact. It proves to the full, of course, that, given an idea, supported by a fair show of demonstration, such a thought is certain to become dominant and overruling in the minds of many men. How far this principle may serve to explain many another delusion of human life, I leave my readers to judge.

[AMERICAN JOURNAL OF SCIENCE.]

RESTORATION OF STEGOSAURUS.

By O. C. MARSH.

IN this journal, in 1877, the writer described a remarkable extinct reptile from Colorado, under the name *Stegosaurus armatus*,* and later a much more perfect specimen of another species, *Stegosaurus ungulatus*, from essentially the same horizon, in the Jurassic Wyoming.† The latter specimen was in fine preservation, and the more important parts of the skull and skeleton, and especially of the remarkable dermal armor, were secured. Subsequently more than twenty other specimens of these and other species were obtained, so that nearly every part of the osseous structure thus became known, and only portions of the dermal armor were in doubt. A fortunate discovery cleared away most of the doubt in regard to one species, *Stegosaurus stenops*, as the type specimen had the skull, skeleton, and dermal armor together when entombed, and almost in the position they were when the animal died.

With this rich material at hand, an attempt has been made to give a restoration of one of the group, and the type specimen of *Stegosaurus ungulatus* has been selected as the basis. This has been supplemented by a few portions of the skeleton of *Stegosaurus duplex*, apparently a closely allied species from nearly the same locality, while some other parts, especially of the dermal armor, have been placed in accordance with their known position in *Stegosaurus stenops*.

The result is given in the engraving, which is believed to represent faithfully the main features of this remarkable reptile, as far as the skeleton and principal parts of the dermal armor are concerned. This figure, one-thirtieth natural size, is reduced from a larger restoration, one-tenth natural size, made for a lithographic plate to accompany the monograph of the *Stegosauria*, prepared by the writer for the United States Geological Survey.

In this restoration the animal is represented as walking, and the position is adapted to that motion. The head and neck, the massive fore limbs, and, in fact, the whole skeleton, indicate slow locomotion on all four feet. The longer hind limbs and the powerful tail show, however, that the animal could thus support itself, as on a tripod, and this position must have been easily assumed in consequence of the massive hind quarters.

In the restoration as here presented, the dermal armor is the most striking feature, but the skeleton is almost as remarkable, and its high specialization was evidently acquired gradually as the armor itself was developed. Without the latter, many points in the skeleton would be inexplicable, and there are still a number that need explanation.

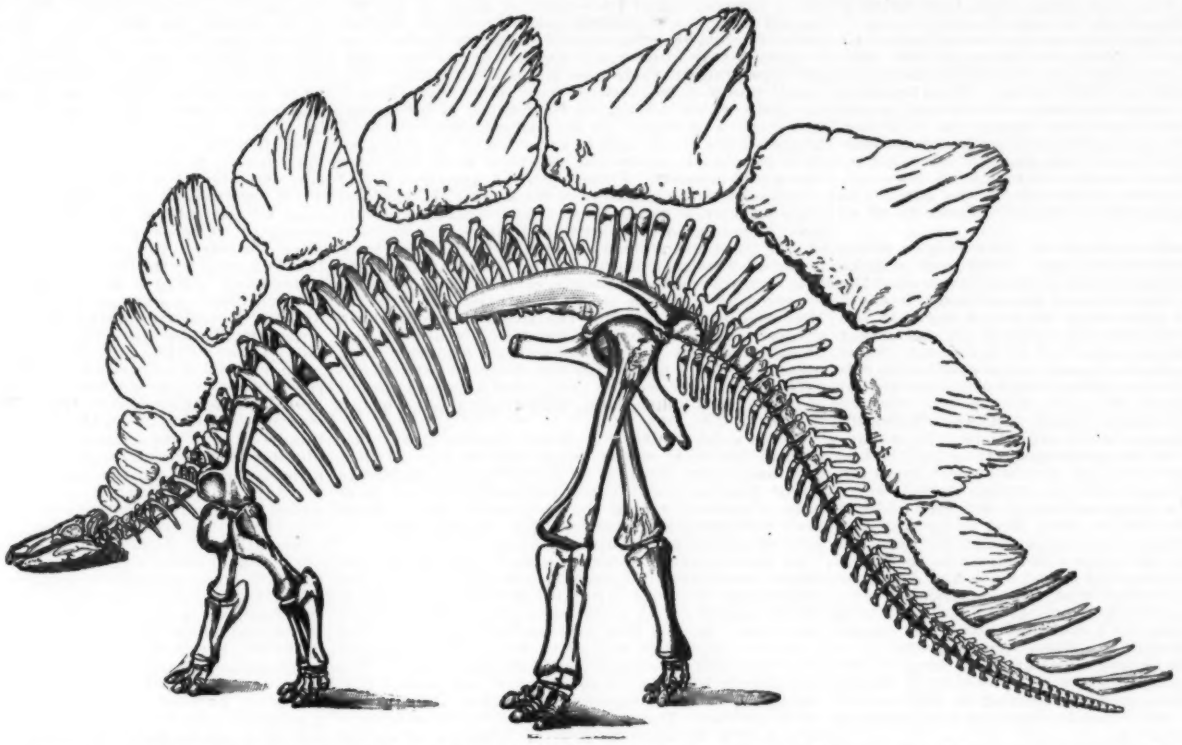
The small, elongated head was covered in front by a horny beak. The teeth are confined to the maxillary and dentary bones, and are not visible in the figure here given. They are quite small, with compressed fluted crowns, and indicate that the food of this animal was soft, succulent vegetation. The vertebræ are solid, and the articular faces of the centra are bi-concave or nearly flat. The ribs of the trunk are massive, and placed high above the centra, the tubercle alone being supported on the elevated diapophysis. The neural spines, especially those of the sacrum and anterior caudals, have their summits expanded to aid in supporting the massive dermal armor above them. The limb bones are solid, and this is true of every other part of the skeleton. The feet were short and massive, and the terminal phalanges of the functional toes were covered by strong hoofs. There were five well-developed digits in the fore foot, and only three in the hind foot, the first toe being rudimentary, and the fifth entirely wanting.

In life, the animal was protected by a powerful dermal armor, which served both for defense and offense. The throat was covered by a thick skin in which were embedded a large number of rounded ossicles, as shown in the figure. The gular portion represented was found beneath the skull, so that its position in life may be regarded as definitely settled. The series of vertical plates which extended above the neck, along the back, and over two-thirds of the tail, is a most remarkable feature, which could not have been anticipated, and would hardly have been credited had not the plates themselves been found in position. The four pairs of massive spines characteristic of the present species, which were situated above the lower third of the tail, are apparently the only part of this peculiar armor used for offense. In addition to the portions of armor above mentioned, there was a pair of small plates just behind the skull, which served to protect this part of the neck. There were also in the present species four flat spines, which were probably in place below the tail, but as their position is somewhat in doubt, they are not represented in the present restoration.

All these plates and spines, massive and powerful as they now are, were in life protected by a thick, horny covering, which must have greatly increased their size and weight. This covering is clearly indicated by the vascular grooves and impressions which mark the surface of both plates and spines, except their bases, which were evidently implanted in the thick skin.

The peculiar group of extinct reptiles named by the writer the *Stegosauria*, of which a typical example is represented in the present restoration, are now so well known that a more accurate estimate of their relations to other Dinosaurs can be formed than has hitherto been possible. They are evidently a highly specialized sub-order of the great group which has the typical *Ornithopoda* as its most characteristic members, and all doubtless had a common ancestry. Another highly specialized branch of the same great order is seen in the gigantic *Ceratopsia*, of the Cretaceous, which the writer has recently investigated and made known. The skeleton of the latter group presents many interesting points of resemblance to that of the *Stegosauria*, which can hardly be the result of adaptation alone, but the wide difference in the skull and in some other parts indicates that their affinities are remote. A comparison of the present restoration with that of *Triceratops*, recently published by the writer,* will make the contrast between the two forms clearly evident.

All the typical members of the *Stegosauria* are from the Jurassic formation, and the type specimen used in the present restoration was found in Wyoming, in the Atlantosaurus beds of the upper Jurassic. *Diracodon*, a genus nearly allied to *Stegosaurus*, occurs in the same horizon. *Omosaurus* of Owen, from the Jurassic of England, is the nearest European ally now known, but whether it possessed a crest of dermal plates like that of *Stegosaurus* is doubtful, although caudal spines were evidently present.



RESTORATION OF STEGOSAURUS UNGULATUS, MARSH. (ONE-THIRTIETH NATURAL SIZE.)

* This journal, III., vol. xiv., p. 513, December, 1877.

† Ibid., vol. xviii., p. 504, December, 1879. See also vol. xix., p. 253, March, 1880; vol. xxi., p. 167, February, 1881; and vol. xxxiv., p. 413, November, 1887.

[Continued from SUPPLEMENT, No. 818, page 13062.]

ASTRONOMICAL OBSERVATORIES AND WHAT IS DONE THERE.

By F. W. LEVANDER, F.R.A.S., etc.

THE more we see the more we want to see, and at various times our friend presents to our astonished gaze sun, moon, planets, stars, and those wondrous whisp-like things we call nebulæ. If we wish to feast our eyes with views of the planets, one or, perhaps, all of the most interesting of that class—Mars, Jupiter, Saturn—may be above the horizon. In Mars we see, as has been happily remarked, the counterpart of our own earth. Up to recent years it was thought to be unattended by any satellite, but in August, 1877, two tiny moons were discovered. That the planet itself has an atmosphere is evident from the fact that when, owing to the inclination of the plane of its orbit to that of the ecliptic, the sun shines more directly on either of its poles, the winter snows which have accumulated there gradually disappear, to be again renewed in due course.

Other markings there are that are permanent, corresponding to our land and water; all these have received the names of former or living men of science. By observations of these streaks and spots, the time of the planet's rotation on its axis has been found to be a little more than 24 hours 37 minutes. Under certain circumstances the existence of these markings can be observed with very small optical power—the writer has seen that there *are* such spots with an object glass of only one and a half inches in aperture; with even a six-inch glass the polar snows appear intensely bright. The planet's diameter is about half that of the earth and its mean distance from the sun about 140,000,000 miles.

The appearance of Jupiter is very different from that of Mars. On his surface we see gray (and sometimes other colored) streaks or belts, which vary in size, shape, and position, but are always more or less parallel to the equator of the planet. His four moons, appearing sometimes on one side of him, sometimes on the other, now passing over, and again hidden by, his disk, owing to their motion round their primary, are always objects of interest to a young astronomer.

To observations of these comparatively small bodies, and to Romer's investigations of them in 1675, is due our knowledge that light is not instantaneous in its movement. We now know that its speed is not far short of 190,000 miles per second. The mean or average distance between the sun and the earth is about 92,000,000 miles, that between the sun and Jupiter about 483,000,000. As both planets are continually moving round the sun, their relative distances are of necessity constantly varying. The light which emanates from the sun and illuminates Jupiter's satellites,

* This journal, vol. xii., p. 339, April, 1891.

and is by them reflected to the earth, has accordingly to travel over distances ranging, roughly speaking, from 400,000,000 to 580,000,000 miles. The fact that the observed times of their motions across and behind the disk of their primary—their transits and eclipses—were not in accordance with those obtained by calculation led to the above-mentioned discovery.

To see Saturn at his best such a concatenation of favorable circumstances is required as seldom occurs in our climate. But if we are fortunate enough to meet with a really good night, what a glorious, all-repaying sight he is! A huge ball, surrounded by rings and attended by a retinue of no less than eight satellites, and who can say that even that large number is not within the truth? The larger the telescope, the more light we can collect, the more shall we be able to discern in this magnificent object. The ball itself, which is 75,000 miles in diameter (nearly 14,000 miles less than that of Jupiter), is crossed by many belts and streaks, varying in position and magnitude, but always, like those on Jupiter, parallel to the equator. Its axial rotation is accomplished in a little over, and that of Jupiter in a little under, ten hours. In observing such faint objects as the markings on Saturn and on his rings, it is the goodness of the observer's eye that tells, as well as the excellence of the instrument. Some persons have much keener vision than others; the mantle of the "eagle-eyed" Dawes seems to have descended on Mr. Isaac Ward, of Belfast.

It must be remembered, too, that it is always easier to see what is known to exist than to make its first discovery. Saturn's rings may well be reckoned among the most wonderful sights in the heavens. What those remarkable appendages consist of no one knows; in the opinion of some astronomers they are composed of an enormous number of small satellites, so close together that, owing to the great interval that separates us from Saturn (his mean distance from the sun is more than 886,000,000 miles), we are unable to discern them as separate objects. Whatever their composition may be, we know from actual observation that these rings are very thin. For convenience sake, that which is outermost is designated A, the next B, and the next C. The existence of these rings was first made known by the observations of Christian Huygens in 1659. The outside diameter of A is no less than 172,240 miles and the inside diameter of C 92,000 miles. When the air is very clear and a powerful telescope is employed, A and B are found to have numerous streaks on their surfaces; in fact A is—at any rate apparently—permanently divided by at least one black space, which is not by any means a difficult object even in a small telescope. Owing to the combined motions of the earth and Saturn, these rings present different aspects to us at different times.

All the planets do not move in their elliptic orbits round the sun in the same plane. If we were to make an orrery, or mechanical arrangement to represent the motions of the planets round their primary, it would not be correct to place them in such a way that imaginary lines drawn from the center of the sun to that of each of the planets should all be horizontal. Some would have to be inclined more, and others less, to this horizontal line, for the orbits of all the planets are not in the same plane. It is, therefore, evident that we shall see sometimes the northern, sometimes the southern, side of the rings, while at other times they will appear edgewise. All the phenomena, from their widest opening to their becoming almost—under some circumstances quite—invisible on account of their edgewise presentation, are gone through for each side of the ring in about fifteen years, that being half the time spent by Saturn in moving round the sun. In certain positions the rings will appear to be almost parallel to the belts on the planet itself, and it is most probably due to this fact that our acquaintance with ring C is of so short a duration. It is not bright, as A and B are, but very faint, and the body of the planet can be seen through it. From this peculiarity it is generally known as the crape or dusky ring. Very little was known of it till it was observed by W. Bond, in America, on the night of November 11, 1850; a fortnight later, but before Bond's discovery was known in England, Dawes saw it.

It was not, however, till nearly two years afterward that the fact of its being transparent was established. Traces of it had apparently been noticed two hundred years previously, but its annular nature was not then established. It is most obvious where it crosses the planet itself, and on this brighter background has been frequently seen with the little one and a half inch object glass previously mentioned. Few telescopes will show all Saturn's moons in all parts of their orbits. Titan, the largest and the first to be discovered (by Huygens in 1655), is very conspicuous; some of the others are exceedingly faint, and their surfaces do not appear to have the same reflecting power. Though anxious to see all that is possible in the Jovian and Saturnian systems, we must remember that a certain amount of light is necessary to insure good definition. The deeper the eye piece is, the more contracted is the field and the more conspicuous and troublesome is any defect in either the telescope or its mounting. We must not, therefore, yield to the temptation of overpressing our magnifying power. Eye pieces which give a magnification of about fifty to the inch of aperture will usually give the most satisfactory results, though no absolute law can be laid down.

Having viewed Mars and the "giant planets" Jupiter and Saturn, which are telescopically the most interesting of their class, we might wish to pursue our investigations and examine the remaining planets. Mercury is best seen in the daytime, for, since his mean distance from the sun does not much exceed 35,000,000 miles, he never appears sufficiently far from his primary to be well seen either before sunrise or after sunset. Nor does he with a diameter of only 3,000 miles present a large disk. Venus, too, is best seen by daylight, though not entirely for the same reason, for her distance from the sun is more than 67,000,000 and her diameter 7,480 miles.

Owing probably to some peculiarity in her atmosphere, she reflects so much of the light that she receives from the sun that when she is most brilliant to the naked eye—and she can then be easily picked up by the unaided vision in the daytime, if her position is known—she is not able to be well seen on the darker background of the morning or evening sky, and at other times her disk is comparatively inconspicuous. Both these planets, being "inferior," or nearer the sun than the earth, present phases similar to those of the moon. Beyond this there is not much to be made out on either.

We now come to planets not known to the ancients. William, afterward Sir William, Herschel, who in later years became so celebrated for his large telescopes and the work that he accomplished, noticed in 1781 a peculiar object that he at first imagined was a comet. It was, however, soon found to be another planet, to which the name of Uranus was afterward given, and the solar system was by this discovery at once extended to a distance of 1,780,000,000 miles. In more recent years four moons have been observed to accompany him. His distance from us is so great that although his diameter is 30,000 miles, not much can be seen on the surface even with the largest telescopes. The same remark applies, but in a greater degree, to that which is, as far as our knowledge extends at present, the most distant planetary member of our system—Neptune, 1,000,000,000 miles more remote from the sun than Uranus, with a diameter of 37,000 miles. We know very little about him and his solitary moon. It is more than probable that we are not yet acquainted with all the satellites of these distant planets. The circumstances attending the discovery of Neptune are most remarkable and most interesting. It can be easily imagined that when astronomers are made aware of the appearance of a heavenly body in a part of the sky where it is known not to have been previously visible, very little time is lost in endeavoring to find out all that is possible respecting the stranger. Consequently, when the body discovered by Herschel—not by chance, be it remembered, but in the course of a systematic series of observations—was found to be in motion round the sun, mathematicians at once set to work to find out its orbit, from which the place occupied by it at any time either before, or after, its discovery could be determined. This having been done, it was found, though not till many years had elapsed, that the planet was not pursuing the path that theory had marked out for it. It was evidently being attracted, or dragged out of its course, by some as yet unknown body, for, according to the conclusion arrived at by Newton, every particle of matter in the universe is attracted by every other particle in a certain manner depending on their mass and their distance. The question now to be answered was, What and where is the body which is dragging Uranus out of his course, and what is its mass? In the calculation of its orbit all the effects of this nature which could be produced on it by planets nearer the sun than itself had been taken into account. From a certain apparent law of progression in the distances of the known planets from their primary, it was assumed that the unknown body must be much more remote than Uranus. The solution of the question involved extreme difficulties. These, however, were surmounted almost simultaneously by two very able mathematicians, each working quite independently—Adams in England and Leverrier in France—and the place of the stranger having been theoretically determined, it was found in almost that identical spot by the telescope. This discovery took place in 1846. A noble triumph, truly, of mathematical skill and a noteworthy instance of a dogged pursuit of knowledge under great difficulties, worthy of all praise.

Between the orbits of Mars and Jupiter it was long noticed that there was an unaccountable gap. This is now found to be occupied by a considerable number of minor planets, about three hundred of which have been discovered within the last ninety years. From their very minute size they are not, telescopically, objects of interest to the ordinary observer.

As the eye piece is merely a small microscope employed to enlarge the image formed in the focus of the object glass or mirror, a number of these appliances is always supplied with every telescope, and the observer can select the one that best suits his purpose. The deeper the eye piece, the larger will an object appear if it has a disk or occupies an appreciable space. But the case is different when we view the stars. For, though they are of enormous size, they are at a still more enormous distance, and with no increase of power can they be made in a good telescope to appear much other than points. Indeed, the better the instrument is, the smaller are the star disks.

Having exhausted the list of planets, it will be worth while to turn our attention to what are commonly known as fixed stars, so called, not because they are immovable, but because they are not wanderers or planets. Still relying on the better knowledge of our friend, we shall probably be shown first some of the stars in the more familiar constellations; and then others which, perhaps less conspicuous to the naked eye, are noteworthy for the beauty of their color, for some are white, others red, yellow, blue, etc. Among the most beautiful of these may be mentioned β Cygni, γ Andromedæ, α Herculis. But we shall not find that all stars are of the same degree of brightness, though this is not necessarily an indication of either their size or their distance. It has been found convenient to divide them into classes or "magnitudes," the brightest being considered of the first magnitude. Few persons can, without optical aid, discern as separate objects stars which are of less than the sixth magnitude, but the order is continued much further for telescopic stars. The determination of magnitudes has till recently been not much more than a matter of estimation; but as science demands exactness, means have been devised of late years, notably by Professor Pritchard, of Oxford, to secure this end. His mode of procedure is to view the star, the magnitude of which is to be determined, through a wedge of darkened glass which can be moved to and fro until a part is reached through which the light of the star can no longer penetrate. The position of the wedge is then read on an appropriate scale. This "method of extinctions" has been found very trustworthy.

Again, it will be noticed that many of the stars which to the naked eye, or even when viewed in the finder, appear to be single, are not so in reality, but double, triple, and even quadruple. In some instances this appearance is due to the fact that one of the stars is nearer to us than its apparent companion, but in almost the same straight line. These, then, are only optically double, but many are really double, being physically connected with each other, though separated by an enormous interval, each circulating round their common center of gravity. Till about a hundred years ago only four such pairs were known, whereas now a complete list would contain about ten thousand. As the relative positions of those that are not merely optically double are constantly varying, it is of great importance to determine them precisely, and it may be interesting to the reader to know how this is accomplished. The eye pieces we have hitherto been using are of such a construction that the focus is between the two component lenses, and are called negative eye pieces. We shall now have to substitute for them another sort—the positive—the plano-convex lenses of which have their convex surfaces facing each other. The peculiarity of this construction is that the focus of the combination is beyond the field lens; this enables us to observe distinctly not merely the image of a star, but also an arrangement of delicate spider lines placed in the common focus of the object glass, or mirror, and the eye piece. As it is necessary for all observers to measure accurately, and in the same manner, the angle which the components of a double star make with each other, there must needs be some fiducial line to start from as the fixed arm of the angle. This is a line joining the true north and south points in the field of view, and indicated therein by a spider line, technically called a wire, which can be placed in that direction, as shown by a divided position circle, usually engraved on the eye end of the telescope. This circle has, of course, its verniers and reading microscopes, together with a mechanical arrangement for imparting a slow rotary motion to the eye piece and its wire. Having then got our new instrument into position, and the larger of the two stars on the wire, all we have to do is to rotate the apparatus from left to right till the wire appears to bisect the other star, when the reading on the circle will show the angle which the line joining the two stars makes with the meridian. In practice a few minutiæ, which are here omitted, must be attended to first, in order to make the observation correct.

But their distance from each other, as well as their relative positions, must be determined. To do this we must avail ourselves of another subsidiary appliance, the parallel wire micrometer. This consists essentially of an oblong box which, with its positive eye piece, can be placed in the eye tube of the telescope. On looking through it we see a fixed horizontal wire and two others in a vertical position, and, therefore, parallel to each other, which can be caused mutually to approach or recede by means of a screw at either end of the box. These screws have large graduated heads, and when the value of one revolution of the screws is determined, we can find the distance of the two stars, the diameter of a planet, etc., by first bringing the wires together, so as apparently to touch one of the stars or one side of the planet's disk, and then by means of its screw causing one of the wires to touch the other star or the other side of the disk in a direction indicated by the fixed wire. The number of turns of the screw will give the angular distance. The double and multiple stars are so numerous that it is very difficult to make a selection, but the amateur will be much gratified by measuring such objects as Polaris, α and ε Lyræ, θ Orionis, and ζ Cancri.

Among the mysteries yet unsolved must be placed the variable stars, the light emanating from which does not remain constant. The first whose variability was noted was α Ceti, which in the course of three hundred and thirty days varies in brightness from that of a star of the second magnitude to invisibility. Some members of this class accomplish their periods in a few days only, while there are others, such a η Argus, which take many years to go through their variations. One of the theories that have been brought forward in explanation of these phenomena is that these stars are accompanied by obscure bodies which revolve either round them or round their common center of gravity.

We shall hardly escape being shown the Pleiades, or Præsepe, or the glorious globular cluster in Hercules, or the marvelous Milky Way, which consists of an infinite number of stars, with which our own system is supposed to have some connection.

A question will naturally present itself to the inquiring mind, At what distance are these stars from us?—a question very difficult of exact solution. If a person were to stand not far from the base of the Westminster clock tower at, say, a quarter past the hour, and another person were to ascend in a balloon until he was at a level with the face of the clock, the two, though watching the minute hand at the same moment, would not agree as to its exact position. When the quarter is struck, he who is on a level with the clock will notice that the hand has reached the III, but to an observer at the foot of the tower it will appear to be about fourteen minutes past the hour. This apparent difference is due to parallax—"the apparent change of place which bodies undergo by being viewed from different points." Astronomers have endeavored, and in some few instances successfully, to find the distances of stars from us by noting the exact position in the heavens they appear to occupy at a given time and again six months afterward, that is to say from another standpoint more than 180,000,000 miles removed from the former one. The resulting annual parallax, as half the difference of the two positions is called, when cleared of all effects produced by other causes, is most minute, and in the case of many stars quite inappreciable. But the number of miles of distance thus represented is bewildering in the extreme, and in their stead the time occupied by light passing over the interval between the star and our earth is adopted. Light traveling unceasingly at the rate of close upon 190,000 miles in every second takes more than forty years to reach us from the Pole Star, or, to put the same fact in a different way, if the Pole Star were in some way destroyed to-day, we should not become aware of its destruction till after the expiration of more than forty years. So far as our present knowledge extends, the nearest fixed star is α Centauri, which is 275,000 times as far from us as we are from the sun, and the light from which takes no less than four and a third years to reach us.

While moving the telescope about in our explorations among the stars, we shall not fail to come across numerous misty, cloud-like masses, which resemble patches of dim light seen on the dark background of the sky. These are the nebulæ which are scattered, apparently in accordance with no law, over all parts of the heavens, of all conceivable shapes and of inconceivable magnitude. As early as the tenth century a curious object, evidently not a star, had been observed in the constellation Andromeda, by a Persian astrono-

mer named Suñ, but it was unknown to Europeans until discovered in 1612 by Simon Marius. It is, however, so conspicuous as to be easily seen by the naked eye. This nebula has been traced to a length of 4° and a breadth of 2½°. Some idea of its apparent size may be formed if we consider that the mean apparent diameter of the sun is only half a degree. The great nebula in Orion has been traced to a still greater distance, as far as 5½° in length and 4° in breadth. Their sizes are, however, as far as appearances go, quite exceptional. The dumb bell nebula in Vulpecula, that in Lyra which resembles a ring, and the spiral nebula in Canes Venatici, not to mention hosts of others, are well worthy of attention. Some astronomers have held the opinion that in the nebulæ we have evidences of the beginnings of worlds, others that they are only enormous aggregations of stars, but at such vast distances as to be irresolvable. It was reserved for the spectroscope to make a more accurate determination of their nature as well as of that of the stars.

By allowing a ray of sunlight to pass through a slit in the shutter of a darkened room, and to fall upon a prism of glass (prefe.ably flint), it will emerge in the form of a colored band. The simple arrangement thus formed may be improved by using a number of prisms so arranged that when the light emerges from one it enters its neighbor, and so on. This secures a greater amount of dispersion, and causes the band to be of much greater length than it would otherwise be. On examining the colored band with a small telescope, we shall see that it is striped with a multitude of dark lines at right angles to its length. Although many of these lines were noticed by Wollaston in 1802, and examined and mapped out by Fraunhofer and others, it was not till 1859 that Kirchhoff was enabled to interpret their meaning. This may, perhaps, be made clear by the following simple experiment. Instead of making use of the sun for our source of light, let us take a Bunsen burner, in the flame of which a small portion of the metal sodium has been placed. On viewing the band, or spectrum, thus produced, one is at once struck by its utter dissimilarity to that which is formed when sunlight is employed. It is neither covered with colored bands nor streaked with dark lines, but in a certain position—which is always the same relatively to the length of the spectrum—there is one bright yellow line. Now let us take a second burner, also with a piece of sodium in its flame, and arrange the two lights and the slit in such a manner that all are in one and the same straight line. The colored streak is gone, and a black line appears in its stead, occupying identically the same position. On performing similar experiments with other substances, it will be invariably found that wherever colored lines are seen in the first instance, when the two flames are used they will be replaced by dark ones. Spectra with dark lines are known as absorption spectra, for the vapor of, say, sodium has the power of absorbing rays of the same refrangibility as those emitted by itself. A spectroscope attached to a telescope in lieu of an eyepiece enabled Huggins, "the father of spectroscopy," to assert in 1864 that the light of certain nebulæ consisted of glowing vapor. The question of the constitution of—at least many of—the nebulæ has thus been answered. The spectroscope has also been successfully applied to such few temporary stars as have been observed to burst forth with a sudden intensity of brightness and then wane. On May 12, 1866, a star of the second magnitude was noticed in a part of Corona Borealis where the observer, Birmingham, of Tuam, felt certain that it had not, at any rate in its then brightness, formerly existed. That no star of that magnitude was visible there four hours previously was certified by another observer. The application of the spectroscope revealed the fact that its very sudden increase of brightness was due to incandescent hydrogen. The actual result of such a terrible conflagration will, perhaps, forever remain unknown to us. T Coronæ was literally a nine days' wonder, for at the expiration of that time it had become a mere telescopic star.

In many almanacs we find, against certain days, an intimation that meteors may then be expected. Hardly an hour elapses on a clear night without one or more of these small erratic bodies being seen to pass athwart the sky, and sometimes leave a trail of light, occasionally also bursting into many fragments. In fact, many thousands of meteors enter the earth's atmosphere in the course of the year. The Leonids, so called because they appear to emanate from the constellation Leo, have been for very many years noticed on the nights intervening between November 11 and 15. The brilliancy of the shower varies in different years, and reaches a maximum once in thirty-three years; the last display of this nature, when "the heavens seemed to be on fire," occurred in 1866. The radiant points of about a hundred of these meteor showers have been determined with a very considerable amount of accuracy. Schiaparelli found, in 1866, that the path pursued by the August meteors, the Perseids, was identical with that of the orbit of a bright comet which had been seen in 1862. Here, then, was a discovery which seemed to bear on the nature, not of meteors only, but of comets as well. Other astronomers followed the example thus set them, and the identity of the November meteors and Tempel's comet of 1866 was soon established, as well as that of the April Lyraids and a comet which had appeared in 1861. As meteor showers reappear after a certain time, it is evident that they are parts of our system, and pursue very elongated elliptic paths, as do many comets, unless attracted from their course into hyperbolic or parabolic paths by some more powerful body than our sun.

All comets do not present the same appearance in the telescope, but they have several features in common. Most of them have tails, though they are sometimes inconspicuous in consequence of their distance or size, or their position relatively to the sun and earth; while nearly all have a head, which, when examined in the telescope, usually appears surrounded by envelopes. When a comet first comes into visibility, it generally appears small, and looks somewhat like a misty star—a hairy star, as the name implies. As it gets nearer the sun a tail is thrown out, increasing in length until the comet is lost to sight from its proximity to the sun, to reappear on the other side of the orb of day, grow fainter, and gradually disappear in the realms of space. The most striking comet of recent years was undoubtedly Donati's, named after the astronomer who discovered it at Florence, June 2, 1858. Not till nearly three months after its discovery did a tail begin to appear, or the comet itself to be visible to the naked eye. It was not finally lost sight of till March 4, 1859. Whatever comets are composed of, their mass is very slight, and their constituent matter of such a nature as to allow even faint stars to be seen through them without loss of brightness. The spectroscope shows that comets do not shine, as was formerly supposed, merely by light reflected by them from the sun, but that they are partly self-luminous, and that their gaseous surroundings contain, at any rate, hydrogen and carbon.

In our somewhat desultory inspection of the heavens, we have viewed some of all the different sorts of celestial bodies, but the two with which we are most intimely concerned have been purposely reserved till the last.

When observing the sun telescopically, it is of the utmost importance that the eye should be protected by some special contrivance from the excessive heat and light concentrated in the focus of even a small mirror or object glass. The simplest plan is to attach to the end of the eye piece nearest the eye a "dark head," or glass of some dark color. The disadvantages attending this method of viewing the sun lie chiefly in the fact that the only means of adjusting the amount of light received is to change the dark head in use for another of a greater or less degree of transparency. The operation, though slight, takes time, and what might otherwise have proved a valuable observation is marred. Sir John Herschel suggested the use of a diagonal eye piece, which consists of a tube, open at both ends, sliding into the eye end of the telescope, and having another shorter tube at right angles to itself. In the latter is placed the eye piece, opposite which, in the longer tube, a piece of plain unsilvered glass is fixed at an angle of 45°, or, better still, a small prism. By these means about $\frac{1}{13}$ of the light, and very little of the heat, is reflected. The diagonal eye piece is also a great comfort when viewing objects near the zenith with a refractor. A polarizing eye piece is a still greater luxury in solar observations, since it permits the degree of illumination of the image to be adjusted to a nicety. When light falls on a plane glass surface at a certain angle, the reflected rays are polarized, and if then permitted to fall perpendicularly on a plate of tourmaline, capable of being rotated, the quantity of light transmitted can be varied at will. Dawes' solar eye piece is another contrivance for the same purpose. Briefly, it consists of three circular plates, each of which is capable of independent rotation. In one is a series of circular apertures varying from $\frac{1}{16}$ to ½ inch in diameter; in the next some single lenses; and in the outermost dark glasses of different shades. The lenses have to be focused by a rack and pinion movement. It will be seen that the instrument is rather complicated. A solar and sidereal diphragm eye piece of simpler form, devised by the writer some years ago, will be found described in the "Monthly Notices" of the Royal Astronomical Society. In this the variable size of the aperture is produced by a single screw movement. The sun may also be viewed with very great comfort and ease by projecting its image on a piece of card attached to the telescope at right angles to the line of sight.

Having fitted one or other of these contrivances to the telescope, we shall, on viewing the sun, be at once struck by the peculiar mottled appearance of his surface. This is always more or less visible, and is due to intervening spaces of different degrees of brightness. Nasmyth, in 1860, considered that it was caused by a multitude of interlacing masses somewhat resembling willow leaves in shape; while Huggins and others are in favor of the term granules, or rice grains, in describing these luminous particles. Bright streaks or faculæ are frequently seen in the neighborhood of the equatorial region. Much more easy of observation are the dark spots first described by Galileo. These vary very much in size, and not unfrequently attain such enormous dimensions as to be visible to the naked eye. The distance of the earth from the sun is, it will be remembered, about 92,000,000 miles, and the real diameter of the latter rather more than 866,000 miles (though we have good grounds for assuming that it is but a small star), and its apparent diameter differs very little from half a degree.

It has been found that spots subtending an angle of not less than 50 seconds of arc (which represents a diameter of 24,000 miles) can be seen without instrumental aid through a mist, or by the mere intervention of a dark glass. Single spots have been known to measure forty or fifty thousand miles in diameter, while many groups have been observed covering areas of more than one hundred thousand square miles. The region of spots is usually confined to a broad space extending 5° on either side of the sun's equator. From observations made by Schwabe during the long period of forty-three years, not a single clear day in which was allowed to pass without a careful scrutiny of the solar surface by his "imperturbable telescope," and the counting of the number of spots visible thereon, he came to the conclusion in 1844 that they were of a periodic character, and attained a maximum once in about every ten years. By a more rigid determination Wolf, in 1852, found that a period of 11·11 years more nearly satisfied the conditions. What these spots are, what causes them, and what effects their destruction—sometimes almost momentary—we know not with any degree of certainty. We do know that magnetic storms on the earth are in some way connected with them. They present the appearance of dark spots of irregular shape, to which the name umbra has been given, surrounded by a penumbra or lighter border. A nucleus of still more intense darkness has sometimes been detected within the umbra; its blackness is most probably not real, but merely the effect of contrast. From the movement of spots, it has been found that the sun rotates on its axis once in twenty-five and a quarter days.

When, during total eclipses of the sun, the dark body of the moon comes between him and us, and the intense light is thereby cut off, rose colored prominences, or red flames, are seen at his edge. Under the most favorable circumstances, the period of totality rarely exceeds a few minutes—too short a time for a minute investigation of these phenomena. It was, therefore, with no small amount of satisfaction that astronomers learned in 1868 that Lockyer and Jannsen had independently discovered a method by which prominences could be observed on the uneclipsed sun. The spectroscope revealed the fact that they are glowing masses of hydrogen, reaching to enormous distances, occasionally extending from the sun's surface for nearly a quarter of his diameter, and presenting all sorts of fantastic shapes. Since that time, improvements in instrumental means and in the mode of observing have led to the knowledge that, by widening the slit of the spectroscope, the flames themselves may be seen at any time at the limb of the solar disk. There is no doubt that a very close connection exists between spots, faculæ, and prominences, and one in which it will be found that electricity plays a very prominent part.

If the sun were a thin shell (and, as a matter of fact, we know that not only that body, but all the planets exterior to the orbit of Mars, are not composed of solid materials, as our earth is), and it were possible to place the earth at his center, there would be room for the moon, with its diameter of 2,165 miles, to revolve round it at its present distance, and leave a marginal radius of not far short of 187,000 miles. As our nearest neighbor, and, in a very great measure, the cause of the tides, our moon and its motions are of great interest. As a telescopic object it is a dead world, subject to no change, and consequently we are enabled to study its surface at leisure, more especially as, the period of its rotation on its axis and of its revolution round its primary being performed in similar time, the same face is always presented to us. The observer will immediately notice that the moon's comparative proximity to us necessitates an alteration in the position of the eye piece, in order to obtain distinct vision. To the naked eye the lunar surface presents a somewhat mottled appearance, due to the unequally reflective quality of its material. The moon, in its varying path in the heavens, is constantly passing between us and some star or other. During these occultations the light of the star is instantaneously snuffed out, as it were, when overtaken by the moon's limb, and its reappearance is as sudden. This could not be the case if there were a lunar atmosphere of even extreme tenuity; consequently no water can exist there, although the gray plains formerly received, under a false impression, and still retain the name of seas. When about to observe the moon, especially with a large telescope, it will be advisable to use a light neutral tint sunshade (Venus, too, is best seen thus in the morning or evening), or a power sufficiently high to reduce the glare. On its surface are plains and valleys, mountain chains and craters, isolated hills and ridges, rills, faults and clefts. The shadows cast by the mountains and other formations give us a knowledge of their contours, and by the aid of the micrometer, their actual dimensions can be determined. The crater mountains are, as Webb observes, "the grand peculiarities of the moon; many thousands of these have been delineated, all presenting more or less the same features—a terraced ringwall with a central hill. From sunrise on the moon to sunset, the shadows are perpetually changing, except, of course, when the moon is full and nothing prevents the reflected sunlight reaching us from all parts of the surface. It is for this reason that the moon is not nearly so interesting an object when full as when it presents a crescent or gibbous shape. These crater mountains are on such a vast scale, relatively to the size of the moon, that the few crater plains which are known to exist on the earth sink into insignificance in comparison; the diameter of Copernicus, for instance, is fifty-six miles, and it has a peak rising to a height of 13,500 feet. The most noticeable features of the full and nearly full moon are the systems of bright streaks which emanate from a few of the craters, especially Tycho. These curious rays are not caused by their being elevated above, or depressed below, the surrounding surface; nor has any satisfactory explanation of their presence been hitherto brought forward. One of the most remarkable formations is the Straight Wall, well described by its name, extending for sixty miles, and having a uniform height of 1,000 feet. There is so much variety in the lunar surface that the study of even one detail may well occupy a considerable time; if the observer is a good and rapid draughtsman, he will act wisely in making drawings of what he sees. At any rate he should have a note book, and make records therein at the time of observation. Never should he trust to the next day's recollections, for doubts will certainly arise. It is only by making, preserving, and afterward comparing, careful records that we can hope to detect any changes in the heavenly bodies.

Hitherto all our observations have been made with the equatorial and its appliances, but the astronomer needs other instruments. It is essential that the time of every observation should be accurately noted; he must, therefore, have the means of finding the true time, and for this purpose a transit instrument is required. This consists of a telescope very carefully mounted, so that it can be moved only in the plane of the circle which passes through the north and south points. The object glass need not be large; in the case of portable instruments the aperture is seldom more than two inches, but in large observatories this size is often much exceeded; the Greenwich transit circle, for instance, has a telescope with an object glass eight inches in diameter. The value of the instrument does not depend on its light-gathering quality, but upon the rigidity of its mounting and the accuracy of its single movement. Attached to one side of the mounting is a graduated circle, and by means of verniers moving with the telescope (or *vice versa*) the inclination of the latter to the horizon is known. Having found from the almanac the altitude of a bright star, it is evident that, if the telescope is adjusted to that angle, the star will be seen in the field of view when crossing the meridian. The interval between two consecutive passages of the same star over the meridian is a sidereal day, whereas the length of the solar day is determined by two consecutive meridian passages of the sun, and differs slightly from the former, the value of which is 23 h. 56 m. 4·091 s. Clocks are made to show sidereal time, and one such is always within view of the observer when stationed at the transit instrument. But the size of the field of view depends on the power of the eyepiece used, and the accurate determination of its center, that is, of the position of the meridian, is well nigh impossible.

Evidently some contrivance must be adopted, and we again call the services of the spider to our aid. A positive eyepiece being used, at its focus is placed an arrangement of wires (web), generally five in number, one horizontal and passing through the center of the

field of view, bisected at right angles by a second, the others being placed at equal distances on either side of, and parallel to, the central vertical wire. By noting the times at which a star, moving along the horizontal wire, appears to be bisected by each of the vertical ones, its passage over the middle wire, or, in other words, over the meridian, is easily determined. When the first point of Aries is on the meridian, a sidereal clock shows 0 h. 0 m. 0 s. Knowing the sidereal time and the right ascension of the star whose transit we wish to observe, it is easy to find the mean time at which that phenomenon will take place, and thereby, if necessary, we can correct our mean time clock. It is usual to select suitable objects from a list of clock stars, whose places have been determined with a considerable amount of accuracy.

As the wires of the eyepiece are invisible on a dark night, provision is made for their proper illumination. The axis of the transit instrument consists of two truncated cones, one of which is hollow, in order to permit the light from a suitably placed lamp to impinge on a mirror placed in the main tube at an angle of 45°, by which it is reflected to the wires. A somewhat similar arrangement is generally adapted to the equatorial. Before "taking a transit" one must notice the time by the clock, and then count the ticks of its seconds pendulum, estimating the intervals to the tenth part of a second. This is distinguished as the "eye and ear method," and is being gradually superseded by the use of electrically controlled chronographs. A barrel, on which may be placed a sheet of paper divided into small squares, is kept revolving by clockwork at a certain rate. Insulated wires conveying a current of electricity are led from the chronograph to the eye end of the transit instrument or the equatorial, and mechanism is so arranged that when the observer presses a spring and thereby "makes contact," a lever is depressed and a mark made on the paper of the chronograph barrel. The value of the spaces being known, the exact time of the occurrence is thus recorded.

Only a few observatories possess a heliometer. This may be briefly described as an equatorial, the object glass of which is divided into two equal parts. Each half can be moved in its own plane, and in each will be seen a separate image of the object viewed. The angular distance of two objects not very far apart can in this manner be exactly determined. It need hardly be said that the details of construction in such instruments demand a very considerable amount of care.

One branch of the science remains to be mentioned —celestial photography; and with a brief account of it our imaginary visits to the observatory must terminate.

The first successful attempt to make a celestial object record its own image on a sensitive plate was made by J. W. Draper, in 1840. Using a telescope of five inches aperture, he obtained some pictures of the moon, one inch in diameter. Ten years later, pictures of double that size were obtained with the fifteen inch refractor of the Harvard College Observatory, with which instrument Whipple was the first, in July, 1850, to obtain a photographic image of a star, the one selected being α Lyræ. Others soon entered a field which promised such a rich harvest, and two years afterward De la Rue demonstrated the possibility of using the camera attached to a reflector with equal success. In 1857, twelve years after the first solar daguerreotype—a poor one, it is true—had been taken, De la Rue was commissioned by the Royal Society to superintend the construction of an instrument specially adapted for the purpose of photographing the sun. The photoheliograph, which was the result of his labors, has served as the model on the lines of which all instruments of that class have since been made. The first eclipse of the sun to be photographed was that which took place in 1860, and a satisfactory solution was thereby obtained to the question, which had long exercised astronomers, whether the red prominences really belonged to the sun or not. Great strides have been made in the photographic art and new processes have been discovered, enabling operators to secure pictures with greater rapidity and better results than formerly. Rapidity is a very important point, for although ordinarily good clockwork will impart a fairly equable movement to a telescope, it is frequently found to be not sufficiently accurate to enable one to keep the image of a faint star or nebula on exactly the same point of the plate for any considerable length of time. Not merely have sun, moon, planets, stars and nebulæ been photographed, but also their spectra, and thus permanent pictures have been obtained, which can be measured and whose meaning can be interpreted at leisure. Another advantage of photography is that the actinic rays impress on the plate images of stars and nebulæ quite invisible to the naked eye. The most splendid specimens of stellar photographs yet seen were obtained by Messrs. Henry, of Paris. One of their plates discloses the existence of nearly five thousand stars in a small patch of sky in the constellation Cygnus, where only 170 had previously been catalogued. Results so successful as this and many similar ones have led astronomers to the belief that the laborious process of observing and cataloguing objects by the older method involves very serious loss of time, and the principal observatories in the world are now combining in the magnificent project of forming a photographic celestial atlas on a uniform scale. According to the plan adopted we may hope that this gigantic design will be accomplished in the course of about ten years. When this is completed, as it will undoubtedly be, our knowledge of celestial space will be enormously extended, and it is not too much to expect that great discoveries, hitherto undreamed of, will be made. It will be for another generation to form a second edition of this celestial atlas, when, by comparing the two, changes of position among the double and multiple stars, as well as the nebulæ, will at once betray themselves. — *Hardwicke's Science-Gossip.*

EDUCATED STORKS.

THE stork has joined the ranks of performing horses, elephants, wolves, swine and other artists of the animal kingdom.

Although he passes for a sacred bird, yet ornithologists, hunters and peasants know too well how skillful he is in robbing birds' nests and killing young hares.

Several of these winged artists are now performing in the *New Walhalla* near Berlin, in connection with other artists, and were formerly guests of the Zoological Gardens, where they led a quiet life until they were discovered by their manager to be intelligent "*stars.*" They enter together upon the stage, jumping merrily around with loud clapping of their wings, jump through hoops, mount ladders, and go over all sorts of hedges, half flying and half running. They are protected from accidents, etc., such as breaking their legs, by mattresses upon which they fall as in any first class circus.

The head stork falls with comical grace as though shot dead, and does not rise until he is commanded to return to life.

"*Blondin,*" a skillful rope dancer, earns much applause; he walks backward and forward, stands on one leg and keeps his position, undisturbed by drums, trumpets, clapping of hands, and snapping of whips.

The exhibition closes with a charming scene representing the storks' well known relations to the children's world.—*Illustrirte Zeitung.*

EDUCATED STORKS.

ORIENTAL EXPLORATIONS.

ALTHOUGH for many years Germany has occupied the leading position in oriental studies and the work of her students has been characterized by a most thorough investigation of the subject, it was not until quite recently, says the *Scotsman*, that the Germans entered the field of oriental exploration. The old museum at Berlin, built in 1828 by Frederick William III., remained for a long time without any Oriental collection. From time to time consuls in various parts of the East forwarded objects to the Prussian museum, and one of the best collections is that of oriental gems obtained by Baron Petermann during his travels. In the year 1845 there was discovered at Larnaca, in Cyprus, the site of the ancient Kition, a black basalt monolith with the figure of an Assyrian king upon it, the front and sides of which were covered by a long inscription in archaic characters. Previous to being noticed by European archæologists, the sculpture had been sawn in half lengthways, and the back portion of it was known to have done duty for some years as the counter in a baker's shop. The larger portion was obtained by Mr. Ross, a well known Eastern traveler, for the Royal Museum at Berlin, and was found to bear an inscription of Sargon II., B.C. 721, the conqueror of Samaria, who sent the monument to Cyprus to be erected after having received tribute from the kings of that island.

Anxious to have, at least, some representative examples of Assyrian art, the late Baron Von Bunsen, Prussian Ambassador in London, obtained casts of many of the best of the sculptures obtained by Sir Henry Layard. It was not until the year 1888, however, that Germany began to take an active part in oriental exploration. In 1886 and 1887 a private expedition had visited Babylonia and the districts of Northern Syria; and the report brought back by this mission was so satisfactory that it was determined to take more systematic measures. This resulted in the formation of the Oriental Committee, under the presidency of the well known archæologist, Professor Von Kauffmann, which numbers among its members almost all the best known archæologists and orientalists in Germany. The first work of this committee was to dispatch an expedition to Asia Minor to study the Hittite antiquities. Having traversed the great military and commercial road which intersected the country from the slopes of the Taurus to the shores of the Ægean, the expedition, which was under the direction of Dr. Humann, decided to commence operations at a site where some antiquities had been obtained a few years previously. The mound of Sendscherly is situated on the old road which leads from Marash through the plain of northern Syria along the eastern slopes of the Taurus down to the Gulf of Alexandretta, the ancient Bay of Issus. The mound is situated near to a pass through which a roadway leads into the Cilician plain, and was evidently the site of one of the celebrated Cilician gates. The work of excavation brought to light the remains of an extensive palace, strongly built of black basalt and dolorite, and decorated with numerous sculptures in the archaic style of Hittite art. Many of these have been transmitted to Berlin, and of others careful casts have been taken.

The entrance to the palace was guarded by a pair of colossal lions rude and archaic in style, resembling somewhat the lion found at the entrance to the temple of the war god at Nimroud, near Nineveh. They also present a slight similarity to the sphinxes found by Perrot at Eyuk. The sculptures which decorate the building are extremely interesting. They show a curious mixture of the art of Assyria and Egypt—the result of a long-continued contact with both nations. In one example, which perhaps is a gravestone, the fusion of the two styles is very remarkable. On the left hand side of the bass-relief there are portions of the large figure of a god clad in a long robe in the Assyrian style, and wearing turned-up shoes. He holds in his hands a species of rude guitar, and may have been the Hittite Apollo, perhaps another form of the Cypriote Gingiras. In front of the figure is a small table altar with cross legs, and upon it a pile of offerings consisting of bread, fish and the head of a goose or duck.

Now this object is extremely curious, as it is manifestly a copy of the table altar so often occurring on the Egyptian funereal tablets, and which is described as the table upon which are placed all good things. The priest, who stands beside the altar, is evidently one of the *galli* or eunuch priests, with a beardless, effeminate face, having his hair in long ringlets and wearing earrings. He has in one hand a libation cup and in the other a long feather fan. At the bottom of the stole is a representation, apparently of the warrior to whom it was erected, who holds his lance in his hands point downward, indicating death, and leads by his side a horse. The whole style of this monument is very archaic, and may be attributed to certainly the fifteenth century B.C. Many of the forms discovered here are familiar to us in Greek art, and are extremely important as showing the source from which they came, and the enormous influence which the symbolism of Asia Minor had upon the Greek sculptor.

We have the winged horse-headed sphinx, a curious form of Pegasus, the eagle-headed demon and the Asiatic female sphinx, a form introduced into Egypt by the Hyksos conquerors from throughout the shores of the Mediterranean, and on the archaic stole at Olympia and on a Phœnician plaque found in Sardinia. In the figures of Hittite warriors here the form of the shield is very remarkable, as it is exactly the form which the Greek vase painters gave to the Trojan shields, and is also, curiously enough, the form found in the bronzes in the tombs at Spata and in Sardinia. The question now arises, have we any information as to the name of this ancient city kingdom? This we can fortunately answer in the affirmative. In one of the chambers of the palace were discovered the remains of two colossal statues in black basalt, resembling very much in character Phœnician sarcophagi. The larger of these has the head preserved, and represents a curious bearded, and long-locked divinity wear-

ing a horned cap. This is evidently a solar divinity. Upon the body of the figure there is written a long inscription in Aramaic-Phœnician characters, which states that it is the statue of the god Hadad, dedicated by Panamnur, King of Samal. Now Panamnur was a contemporary of Tiglath Pileser III., and paid tribute to him at Damascus in 732, along with Ahaz, King of Judah. The kingdom of Samal was a very old one, and is mentioned as early as 1600 B.C. in the list of Thotmes III. It seems to have been one of the leading centers of the confederacies of Northern Syria. There remains one other very important monument to be mentioned. In one of the rooms was found a stone monolith, about ten feet high, which bore a long inscription of Esarhaddon, son of Sennacherib, describing his conquest of Egypt and the capture of Memphis. The inscription tells how a battle took place on the frontiers of Egypt early in the month of Tamuz, and was followed by two other battles on the 16th and 18th days of the month, resulting in the capture of Memphis on the 22d day of the month, after half a day's fighting. On the front of the monolith is a representation of Esarhaddon, and at his feet figures of two captive kings. One of these is a negro wearing the royal crown of Egypt, with the sacred serpent on his brow, and is evidently meant for Tarhaka, the Ethiopian king of Egypt. The second figure is probably that of the king of Samal. The discovery of this monument is extremely important, as it gives a marvelous description of one of the most important events in oriental history. The discoveries at Sendscherly afford another striking example of the enormous wealth of material which lies buried beneath obscure Turkish ruins, and it is to be hoped that the success of the German Oriental Committee will induce many others to enter this rich field, where "the harvest truly is plenteous but the laborers few."

BOLD-LEAVED HARDY PLANTS.

THE English garden, when properly created, presents many distinct aspects of vegetation, but none grander, more dignified, or richer than the bold-leaved hardy plants, of which the gunnera may be taken as a type. They give dignity to the scenery when rising up by the side of a lake, stream, or pond, develop their splendid leafage in the subdued light of a wood, and form spreading clumps near the lawn where vigorous effects are desired. It is a sorry sight to see in many large gardens stretches of water, the banks bare of leafage, except for the growth of rank weeds. It is in these happy spots that the gunnera or the polygonum, the reed mace, and many plants of similar aspect are most at home, their noble port being in perfect keeping with the surroundings. It is only, of course, the large garden that can give bold effects of this kind, and one of the best examples I know, but, of course, there are many more, is Livermere Park, Suffolk, where the sides of the winding lake are enriched with the groups of gunneras and other fine-leaved plants, not forgetting also the dwarfer types of vegetation, if we may use such a word when writing of the bold and showy Primula japonica. This is planted in large colonies, the flowers of many colors from the clearest white to the deepest blood crimson, and delightful when in full beauty. Gardeners have yet much to learn in this way; but the only requisite is a true conception of rich effects, planting the gunnera, no matter whether the ordinary G. scabra or the bolder leaved G. manicata, at a bend in the stream to bring out its commanding leafage. Many an ill-looking lake, ill-looking simply by reason of its barren edges, has been made a picture of plant beauty cheaply by the use of such plants as I recommend in this short but I hope acceptable paper.

The gunneras deserve first consideration, as they are among the finest leaved plants in cultivation, perfectly hardy, although hailing from South America. We may compare the leaves to those of the finer kinds of rheum, or rhubarb, with the addition that the gunnera sends up strong, thick, and tall flower spikes, sometimes over four feet in height, tapering, and occasionally in the thickest part measuring over four feet in circumference. The leaves are many in number, and we have seen them over seven feet across, gigantic masses of green that it is a pleasure to look upon. Although the gunnera can give a distinctive character to the garden, it is not common, but this may be due in part to an idea that it is not hardy. This is erroneous, and the Kew specimen transferred a few years ago from the herbaceous ground to the shade of the Cumberland mound has weathered many severe winters with little protection. G. manicata is the handsomer of the two, the leaves of immense size, more inclining to kidney shape than those of G. scabra, and therefore giving a bolder effect in the scenery. But both may be used as representing types of the fine leafage. It is a native of Southern Brazil, while G. scabra comes from Chile. Much the same cultural remarks apply to each kind, as they are hardy, but a

GUNNERA PERPENSA.

slight protection, as a covering of leaves, or in very severe winters a canvas hooped over them, will be beneficial, as there is no need to risk their lives for the sake of a little kindly shelter. I have found and also observed that G. manicata is best for the lake or pond side. It seems to have a stronger liking for the water, and with a background of tall grass, or even a close-shaven lawn dipping down into the water, has a noble effect from a distance, an effect that can be obtained in no other way. G. scabra seems to appreciate a drier position; it loves a slight shade, preferring the glints of sun that pierce through the leafage of overhanging trees than strong light or full exposure. Although from these few remarks it may be thought that the gunneras do not require much attention, it must not be considered proper to let them go their own way. Commence well by digging out, where the plants are to go, a large hole, which should have some rough drainage put in the bottom to prevent stagnation at the roots, while for soil use loam with a fair amount of well decayed manure. In some gardens a bed is made for them sunk a few inches below the surface, so that in the summer season ample supplies of water may be given. Although of such striking aspect, they are not slow in growth, making well developed clumps in a comparatively short time. To promote continual vigor give a good mulch every spring. It is strange the great diversity of stature and character that exists in the various members of the same family. We descend from the giant G. manicata to the small-growing G. monoica, while G. perpensa (here figured) is of distinct character, differing in stature, and, as shown by the engraving, in the form of the leafage also from the bolder and more handsome G. scabra, of which a characteristic illustration is also given.

By the exercise of forethought, it is possible to make the garden richly attractive during the summer; here we speak of the garden in the broadest sense of the word, meaning thereby the stream, pond, or ornamental water of any kind. One of the finest effects which has been our pleasure to see was produced by the crimson-flowered Spiræa palmata running into a dense group of Iris Kæmpferi, the one vying with the other as to which should give the most resplendent color. It is not creditable that very little use should be made of this precious spiræa, one of the best of hardy plants, very free and smothered in bloom in the summer months. Plant it by the waterside in large masses, close enough to kiss the water, in the shady recess, and against a background of dark leafage to throw into bold relief the gay flowers. Then we may use by the waterside, or in a group by themselves, the polygonums.

As in the gunneras, so in the knotweeds, there is great diversity of character in the family, ranging from the creeping P. bistorta to the giant P. sachaliense and P. cuspidatum. Of the two, the finest for lake margins, or giving a finish to an island in the center of a broad sheet of water, is P. sachaliense, a native of the Sachalian island, rising over ten feet in height, and carrying large, handsome leafage. It is not so unruly as the Japan knotweed, which runs about everywhere, growing even in a gravel walk as hard as a flint. In Battersea Park, some years ago—and it may be there now—there was a noble specimen of this polygonum on one of the islands, luxuriating at the water's edge. It stood fully ten feet high, and, surrounded with less imposing vegetation, had a striking effect, reveling in the moist soil.

But we have seen this species make a bed by itself on green turf, its tall, stately stem relieving flat surfaces, while in the shady woodland it succeeds well, although deprived of the sun and free air. One often hears P. cuspidatum condemned, and in truth it is a trial to keep its vigorous shoots in check; but a bed of it by itself is very beautiful, especially when the white flowers hang down in graceful profusion from the bending stems. It is then that one discovers that although a weed by nature, behaving as a weed, and perplexing not a little the gardener, it may be put to a good use. It is well planted in St. James's Park, close by the water's edge, and the stems are left throughout the winter. Some may exclaim that in the interests of the garden these should be removed. But the tall, bare shoots of this knotweed are beautiful in their bareness, their rich cinnamon color giving beauty to the winter scene, and for this reason they are permitted to remain. There is a form of P. cuspidatum, named compactum, which is very dense in growth, the deep green leafage prettily wrinkled, and the whole aspect of the plant bushy. It is fortunately without the spreading nature of the type. When gunneras and polygonums are disposed of, there yet remains a goodly list of plants useful for our purpose.

The stately Bambusa metake is adapted for forming a large clump by the water edge, its slender shoots waving in the summer breeze, and giving a tropical aspect to the garden. We shall hear more of this class in the near future, as we find that they are more capable of resisting the trials of English winters than is commonly supposed. A large clump was removed to the waterside of a large round pond, and came through the ordeal well, sending up now a wealth of graceful shoots to enrich the scenery. A good loamy soil is required, and a commencement be made with fine healthy plants, but the first year little progress will be made. When once well established, however, they produce a profusion of graceful shoots, and with careful watering in dry weather continue to increase in stature and beauty.

Then we can make use of the pampas grass and Arundo conspicua, both dignified in aspect when planted by themselves on grassy slopes leading to water; while the giant fennel and the rheums may be utilized. The rhubarbs are often thought of only in connection with tarts and preserves, but their picturesque growth, luxuriant masses of noble foliage, and stateliness, fit them for the adornment of wild spots or the waterside, where the gunneras are at home. Rich soil is desirable, and use such giant types as R. nobile, R. palmatum, and R. emodi, all with broad, handsome leafage, measuring several feet across. From rheums we come to the graceful Carex paniculata, very pretty as a clump by itself on the turf, as we once saw it at Pandell Court, Bletchingley, and pass on to the reed mace, Typha latifolia; Cyperus longus, the water dock, Rumex hydrolapathum; not forgetting the bulrush or the flame flowers, sometimes called tritomas, and kniphofias. Few think of planting these gorgeous flowers by the waterside, but when the site is well prepared, the situation warm, not too damp, and a light, rich compost used, they grow vigorously and bloom well. In the course of this paper a few good, hardy plants have been pointed out for the adornment of the large garden, in the efforts to promote a more natural, more picturesque, and more effective type of gardening.—*J. E. S., in The Gardeners' Magazine.*

GUNNERA SCABRA.

PRESENT STANDING OF THE SEVERAL HYPOTHESES OF THE CAUSE OF THE GLACIAL PERIOD.*

By Pres. T. C. CHAMBERLAIN, of the University of Wisconsin.

Two important determinations, recently made, have a radical bearing upon current hypotheses respecting the cause of the glacial period. The first is the approximate delimitation of the glaciated area; the second is the demonstration of the low and flat altitude of a large section of that area during the time of glaciation.

I. Through the explanations of Dall, Dawson, Russell, O'Connell, Tyrrell, and others in the northwest it has been satisfactorily shown that the great lowland area of glaciation of North America is limited to the

* Read before the Geological Society of America in Washington, 1891.

northeastern quarter. The explorations in Alaska have been sufficiently extensive and trustworthy to demonstrate that its lowlands have not been glaciated. It would appear from O'Connell's account that even the northern extremity of the Rocky Mountains was not covered by ice. The great drift area of the northeast finds its limitation along the base of the Rocky Mountains. It has nowhere been shown, as yet, to even press hard up against the foot of these mountains, but for the most part stops some notable distance short.

There was, it is true, very considerable Alpine glaciation along the Cordilleran range, but this was almost strictly montanic. On the east side the mountain glaciers have nowhere been shown to have pushed out on the plains to any notable degree. On the west side, where the glaciers were fed by the moist winds of the Pacific, they crept down to the sea level in considerable volume. The inter-montane valleys north of 48° latitude were quite largely occupied by ice, but this is not true of the Cordilleran tract of the United States below the extreme northern border.

While, therefore, the Cordilleran belt was considerably more affected by Alpine glaciation than at present, it has been demonstrated beyond question that it was not the source from which originated any notable part of the great lowland glaciation of North America.

It does not stand to the glaciation of this country in the same relation that the glaciation of the Scandinavian mountains stands to that of the plains of northern Europe. This difference is, in my judgment, radical in its significance. At present, the conditions of glaciation on the western side of North America are much more favorable than those of the western side of Europe. The present west American glaciation is very much more extensive and active than the west European in corresponding latitudes and at corresponding elevations. This accords with theoretical deductions, since the Pacific Ocean is broader and more competent to saturate the winds that pass from it to the land. Taking present glaciation as a basis, it is obvious that any agency which extended glaciation proportionally upon both continents would have buried the whole of North America above 40° latitude with ice radiating from the Cordilleras before the insignificant Scandinavian ice fields could have crept across the plains of Russia and Germany. In comparing modern and ancient glaciation in Europe, it is natural to regard the latter as but an extension of the former, and, if attention be confined to this field alone, any hypothesis, otherwise rational, that accounts for an extension of glaciation from present centers satisfies the conditions of the problem. But not so on the American continent. The great American glaciation radiated from lands of low or moderate elevation now entirely free from ice, so far as known. The investigations of Bell and others appear to have clearly shown that the ice movement of Hudson Straits was eastward and that of northern Labrador northward, and evidences of counter movement are absent. These seem to signify that Greenland was not the source of the Canadian glaciation. Theoretical considerations strongly support this. The broad, deep valley of Davis Strait and Baffin's Bay is sufficient to have borne southeastward and discharged into the Atlantic basin all ice issuing from the fields of Greenland.

If the freezing of the bay and straits prevented this by iceberg flotation, simple glacial flow would have accomplished it. Greenland appears, therefore, to be excluded as a center of dispersion for Canada and the United States. The Canadian center, even if narrowed to the Labrador highlands, is now comparatively low, while the ice spread forth from 1,000 to 3,000 miles over smooth plains of low present altitude.

So far as I have been able to learn, the great plains of Siberia, like those of Alaska, are free from evidences of Pleistocene glaciation. In the mountains and high plateaus of south Siberia it appears, from the accounts of Kropotkine, that glaciation was somewhat extensive; but, unless there be evidences with which I am not familiar, Siberia is not to be reckoned among the areas of lowland Pleistocene glaciation.

Gathering the facts together, and setting aside Alpine glaciation as a local, topographic phenomenon of secondary significance, the great areas of glaciation are found to lie in the northeastern quarter of North America and the northwestern quarter of Europe. Of these areas, the American is, roundly speaking, twice that of Europe.

Now these areas are almost completely included between the meridian of 60° E. long. and its complement 120° W. long. A plane passing through these meridians throws the glacial area almost wholly into the hemisphere which embraces the Atlantic and centers on the meridian of 30° W. long. The area is in no sense circumpolar, but is distinctly one-sided. Its configuration resembles that of the ice-buried Antarctic continent of to-day, but its maximum diameter is 20° greater.

Now, to my view, these facts of distribution are seriously damaging, if not entirely fatal, to all astronomical hypotheses of the cause of Pleistocene glaciation. Terrestrial facts remaining as they are, any extra-terrestrial agency must necessarily, *ceteris paribus*, affect all longitudes essentially alike. The resulting glaciation would be distributed symmetrically about the pole, so far as terrestrial conditions permitted. I have already shown that the terrestrial conditions on the northwestern side of North America are more favorable to glaciation than those on the northwestern side of Europe. It would seem a necessary consequence that any extra-terrestrial agency that developed the Scandinavian glaciation, so as to cover the plains of Russia and Germany, would have developed the glaciation of the north Cordilleras so as to have covered still more extensively the plains of Canada and the United States; and, on the other hand, it would seem that any extra-terrestrial agency that developed a Labradorian glaciation, so as to cover extensively the great plains of the Mississippi and the McKenzie, would have developed at least some striking degree of glaciation in northeastern Asia.

The hypothesis of Croll, which is semi-astronomical, attempts to escape the weakness of the purely astronomical hypotheses, by making large appeal to the configuration of the Atlantic. The eastern protrusion of South America is held to have been extremely potential by alternatingly turning northward and southward the warm equatorial currents of the mid-Atlantic. Now, whatever may be the competency of this, so far as European glaciation is concerned, it seems to me altogether inapplicable to the glaciation of North America, *i. e.*, to the central ground upon which the battle of hypotheses must be fought out. Whatever might be the European effects of warm currents thrown into or out of the North Atlantic, I cannot understand how they could be effective over an area stretching westward, *i. e.*, to the windward, 2,000 miles or more. No change of eccentricity or configuration of the Atlantic could have reversed the westerly winds that sweep across the plains of North America, and I think it may be confidently assumed that no change of temperature in the North Atlantic could bring glaciation to the plains of central and western North America in latitudes as low as 40° and 50°, and lying from one to two thousand miles back from the ocean to windward. If the North Atlantic were frozen over, I do not imagine that it would reduce the temperature of Illinois or Kansas to a point that would tolerate glaciation, or that any effects it might produce on the immediate oceanic border could be propagated a thousand or two thousand miles to the westward. From being at one time almost a disciple of Croll, I have come to feel that his hypothesis absolutely breaks down in its application to the great glaciation of the plains of North America, and a similar conclusion seems inevitable in respect to all astronomical hypotheses.

II. In a paper read on Saturday before the American Association for the Advancement of Science, I endeavored to present a synopsis of data that have been for some time gathering, which force the conclusion that during the several successive stages of the earlier glaciation in the Mississippi basin the surface was lower and flatter than at present; that during the maximum of the later glaciation, the surface altitude was not greatly different from the present, though possibly slightly higher, and that during the closing stages of glaciation the altitude was again lower, descending even below the present position. Nowhere in the broad stretch of the Mississippi basin, an area having a reach of a thousand miles or more in longitude and 600 miles in latitude, an area in which the Pleistocene ice deployed itself as nowhere else on the globe, and left at least a dozen marginal moraines, each one telling of the conditions of its own stage of glaciation in more or less unequivocal terms, have there been found any evidences of mountainous or high plateau conditions. These conditions I think must have expressed themselves in the drainage and drift of the region, had they existed.

The phenomena of the plains of Europe, so far as I know them, are of like tenor and import. The wide distribution of loess and analogous silts over the drift of South Germany and Russia, the attending evidences of slack drainage found in the river systems of those areas, the attenuated nature of the outer margin of the older drift, corresponding to that in America; the feeble trenching and the undeveloped drainage systems of the later morainic tracts, notwithstanding the more vigorous nature of the ice action, and the glacial waters of that region, combine to testify, as it seems to me, to the absence of great altitude during any of the glacial stages so represented.

If the suggestion arises that we are dealing in these instances only with the border of the great ice sheets and that their centers may have been elevated to the zone of glaciation, it should be observed that much more than the mere border is under consideration. From the limit of drift in Illinois to Lake Superior is upward of 600 miles. From the extremity of the Missouri valley glacier we may follow back along the track of glacial movement for at least a thousand miles without encountering any marked evidences of torrential wash, such as should have been produced in great abundance on the slope of a plain rising from near the sea level to an altitude sufficient to reach the zone of glaciation within the narrow limits which alone the zone of melting could have had in those low latitudes.

I know nothing in existing terrestrial conditions to justify the belief that a plateau of less than ten or fifteen thousand feet elevation, if it had the great dimensions of the glaciated areas, could produce a permanent ice sheet in a latitude as low as 40° or even 50°. If so produced at more northerly latitudes, it is hard to believe that it could have descended to a broad low plain like the Mississippi basin and have stretched out hundreds of miles upon it, reaching down to the latitude of 38°, and approximately to the sea level, without suffering destruction from the sun and the southerly winds that sweep that region.

I am unable to persuade myself that any possible elevation of the Canadian territory north of the Great Lakes could have produced a succession of sheets of ice that would spread themselves out upon the plains of the Mississippi basin to the extent the Pleistocene ice sheets did, and in the manner in which they did, and with the results in drift and drainage that we find under present conditions of latitude.

It appears to me, therefore, that all hypotheses based upon northern elevation are seriously, if not fatally, damaged by the fact that the drift phenomena themselves show that the assumed elevation did not exist contemporaneously with the ice, in at least certain extensive areas. And these areas are the very ones upon which the ice extended itself the furthest, deployed itself most completely, and advanced under conditions the most remarkable.

They, therefore, constitute the areas which tax hypotheses the most severely and are the most likely to afford crucial criteria for the determination of their validity. It is of no special value, at the present stage of investigation, to show that northern elevation has existed at some time since the middle of the Tertiary period. To be available as a cause of glaciation, the elevation should be coincident, strictly and accurately, with the glaciation; and to me it seems necessary that the elevation should be essentially coextensive with the glaciation. It seems improbable that the ice in these low latitudes could have descended from the supposed plateau and stretched out to any notable distance on the low south-sloping plains in the face of the destructive agencies of these latitudes. Let any one who is disposed to hold the affirmative compute the time required for an ice sheet to creep several hundred miles, and the amount of ablation a continental atmosphere under a high sun could effect in the time.

III. If extra-terrestrial hypotheses are set aside by the distribution of the glaciation, and if theories based upon northern elevation are set aside because the phenomena of the drift disproved the existence of the elevation at the time of glaciation, whither shall we turn? What hypotheses are left to us? None, so far as I know, in good and regular standing. There have been suggestions of climatic changes brought about by the shifting of oceanic and air currents, the opening or closure of straits, changes in the configuration of the land and consequent changes of the temperature and humidity of the winds, independent of the two great classes of causes already discussed, but they have not been elaborated or supported by a definite array of evidence. I am unable to see any sufficient grounds for believing that modifications of this kind could possibly have been sufficiently potent to produce the vast Pleistocene ice sheets creeping over broad plains down to the warm temperate zone. Judged by the present phenomena of the earth, these hypotheses seem to me quite incredible.

IV. There remains a hypothesis that can scarcely be said to have been seriously advocated in recent years, though mentioned with guarded tolerance by a few investigators, namely, changes in the geographical position of the earth's poles. There has been an inherent prejudice against this hypothesis, because it seemed to take undue liberties with what has been held to be one of the most fixed factors of the terrestrial economy. I sympathize with those who feel a prejudice against the practice of endeavoring to escape the toils of one puzzle by postulating as a cause another more incredible and more difficult of explanation than the first. Astronomers, until recent years, have treated with very light consideration all suggestions that involved any notable change in the position of the polar axis, and geologists have very properly respected their judgment in a matter lying chiefly in their domain. But astronomers have been led in recent years, by the more refined study of their own data, to relax the rigidity of former presumptions and treat with serious consideration the question of changes of latitude. In a paper read on Thursday last before the American Association for the Advancement of Science, Professor G. C. Comstock presented the results of his recent investigations upon the subject of secular changes of latitude. He submitted data favoring the conclusion that during the last 45 years there has been in progress a secular movement of the position of the pole, approximately down to the '69th meridian west of Greenwich, at the rate of four and four-tenths feet per year. This conclusion must, of course, yet be put to the test of further and more refined determinations, and present discussion can only be tentative. A movement in this direction and at this rate continued for about a million six hundred and eighty thousand years would reproduce, approximately, the Pleistocene glaciation of North America on the supposition that the ice then extended away from the pole as far as it now does in Greenland. At any such rate, the slowness of the movement and the great lapse of time required to bring on and take off glaciation are among the weaknesses of the hypothesis, from the geologist's standpoint. Most astronomers are perhaps now prepared to concede that some secular change of the terrestrial position of the earth's axis may have taken place, but they would be slow to admit, on both theoretical and observational grounds, any rapid change at present, and perhaps any great change, even if the time be allowed.

While the earlier glacial deposits stretch far back in time, and from their nature invite rather than oppose a slow-acting agency, the last glacial deposits seem very recent. Glacialists have been inclined to estimate their age by thousands rather than by hundreds of thousands of years. It is very hard to believe that the pole has retreated from the glaciated region at the above rate and has started back again since the last glacial deposits were formed. A more rapid rate or an excessive prolongation of glacial persistence after the original cause had been removed must be postulated to meet the apparent facts. To the glacialist there is no bar to assuming that the pole is now at the turnabout and not under its average headway, or that its movements are accommodatingly varying, but the astronomer must look at the matter more soberly in the light of observed facts and possible causes. To fit the facts of glacial distribution a circuit of a rude triangular form, having sides of about 20° length, with one angle at the west side of Baffin's Bay and another northeast of Iceland, seems the simplest hypothesis. Grant a pole swinging through some such circuit as this, with minor loops, and a proper rate, and the succession of ice invasions and the alternation of warm with cold periods seem to find an explanation fairly fitting the phenomena. Whether any such circuit can be granted must be decided chiefly by the astronomers.

The purpose of my paper is accomplished if I have in any degree loosened the hold of astronomical and orographic theories upon glacialists, on the one hand, and have helped to open the way in any measure to a free and serious consideration of the possibilities of polar movements on the other. It is certainly much too early to positively advocate the hypothesis of a circling pole, but not too early, I think, to advocate a careful study of the distinctive phases of glaciation in the light of working hypotheses built upon this possibility. If they shall prove as barren as their predecessors, as very likely they may, we may still fall back upon the undiscovered resources of the illimitable field of the undreamed-of.

ON THE SOLID AND LIQUID PARTICLES IN CLOUDS.*

IN this paper are given the results of some observations made while on the Rigi in May last, on the solid and liquid particles in clouds. It was noticed, when making observations on the number of dust particles in the atmosphere, that when the top of the mountain was in cloud, the number of particles varied greatly in short intervals; while previous experience had shown that at elevated stations the number was fairly constant for long periods. In order to investigate the case of this want of uniformity in the impurity of clouded air, extreme conditions were selected, and the air tested in cloud and in the clear air outside of it.

When this was done the clouded air was found to have always more dust in it than the air outside.

* Abstract of paper read before the Royal Society, Edinburgh, on July 6, by John Aitken, F.R.S.—*Nature*.

Its humidity was of course also greater. The relative amount of dust in pure and in clouded air varied greatly. Some parts of the cloud had only about double the number of particles there were in the clear air, while in other parts the proportion was much greater. The best example tested occurred on the 25th of the month, when there were observed 700 particles per c. c. in the clear air, while the number in cloud went up to over 3,000, and in one cloud to 4,200 particles per c. c. These observations were taken on the top of the mountain while the clouds were passing over it; the readings being taken in the cloud and again when it had passed and was replaced by clear air.

These observations at once showed the cause of the variability in the number of dust particles in the clouds. The dust acted as a kind of ear mark, and showed that the air forming the clouds was impure valley air, which had forced its way up into the purer air above. This impure air had become more or less mixed with the purer upper air. Where little of the impure air had mixed with the upper air, the number of particles was not large, and the clouding slight; but where the valley air was greatly in excess, the number of particles was great and the clouding dense. It should be noted here that all the clouds tested were cumulus. It is quite probable that the conditions in stratus and other clouds may be different.

During this visit to the Rigi there were a number of opportunities of investigating the water particles in clouds. The apparatus used was the small instrument described to the Society in May last. With this instrument the water particles in clouds can be easily seen, and the number falling on a given area counted. The results are similar to those already communicated to the Society from observations made in fogs during last winter. On observing with this instrument in clouds, the water particles were distinctly seen showering down, and the number falling on the micrometer easily counted. The number of drops falling was observed to vary greatly from time to time. At times so quickly did they fall that it was impossible to count the number that fell on only 1 sq. mm. The greatest rate actually counted was 60 drops per sq. mm. in 30 seconds, but for a few seconds the rate was much quicker. Though the quick falls seldom lasted long, yet 30 drops per sq. mm. per minute were frequently observed for a considerable time. The maximum rate of 60 per sq. mm. per half minute gives 12,000 drops per square centimeter per minute, or 77,400 drops per square inch per minute. This does seem to be an enormous number of drops to fall on so small an area in the time. These drops, however, are so extremely small they rapidly evaporate, more than two or three being seldom visible at the same time on one square of the micrometer. The denser the cloud the quicker was the rate of fall, and as the cloud thinned away the drops fell at longer intervals, and they diminished in size at the same time.

It was frequently observed when the mountain top was in clouds, particularly if they were not very dense overhead, that the surfaces of all exposed objects were quite dry; not only the stones on the ground, which might have received heat from the earth, but also wooden seats, posts, etc., were all perfectly dry, and if wetted they soon dried. While everything was dry, the fog counter showed that fine rain drops were falling in immense numbers. From the fact that the air was packed full of these small drops of water, it might have been assumed that the air was saturated, and tests with properly protected wet and dry bulb thermometers showed that it was saturated. A few observations were therefore made to explain this apparent contradiction of surfaces remaining dry while exposed to a continued shower of fine rain and surrounded by saturated air. The explanation was found to be simply radiant heat. Though the cloud may be so dense it is impossible to see the sun or even a preponderance of light in one direction to indicate its position; yet, as a good deal of light penetrates under these conditions, it therefore seemed possible some heat might do so also. A thermometer with black bulb *in vacuo* showed that a considerable amount of heat penetrated the clouds under the conditions, as it rose 40° to 50° above the temperature of the air while the observations were being made. This radiant heat is absorbed by all exposed surfaces and heats them, while they in turn heat the air in contact with them, and the fine drops of water are either evaporated in this hot layer of air or after they come in contact with the heated surfaces.

The observations made with the fog counter point to the conclusion that the density or thickness of a cloud depends more on the number of water particles than on the number of dust particles in it. The number of the dust particles in the clouds varied too much and too quickly to enable any conclusion to be drawn from observations made in clouds themselves. However, on comparing the thickness of a cloud on the Rigi and a fog at low level, when the number of water drops was about the same, it is found that the fog, though thicker, was not greatly so, although there were only a few thousands dust particles per c. c. in the cloud, while there were about 50,000 in the fog.

The observations with the fog counter show that, whenever a cloud is formed, it at once begins to rain, and the small drops fall into the drier air underneath, where they are evaporated, the distance to which they will fall depending on their size and the dryness of the air. It is thought that much of the dissolving of clouds is brought about in this way.

EXPERIMENTS IN HYPNOTISM AT THE SALPETRIERE.

PARIS, July 29, 1891.—The Salpetriere, the prison hospital of Paris, is to-day the most interesting spot in Europe to those whose duty it is to lessen the physical suffering of the human race.

Here it is scientific men are striving to solve the question of the therapeutics of suggestion—the application of mental force for the curation of disease; commonly called hypnotism. This much has been proved, that suggestion is a physiological cure and that mental phenomena are attended by tissue change in much the same way as are the exhibitions of iodine or any other drug. How this is arrived at is not yet clearly made out, and it is to the solution of this question the schools of Nancy and of Charcot have applied themselves.

Their results have not yet reached to the sphere of newspaper correspondence, for the workers, having in mind the deplorable failure of the experiments in the laboratories of Koch and Brown-Sequard, have persistently refused to allow their results to go abroad beyond the profession until the success or failure of them should be amply verified. The directors, however, showed no objection to having the actual facts stated, so long as no unwarranted conclusions were drawn. Around the subject has grown up a new literature, with new terminology, which gives a survey of all that is important in the province of applied suggestion or hypnotism, though by the term hypnotism is meant a very different thing from what is called by that name by traveling lecturers and unscientific writers.

Hypnotism as carried on at the Salpetriere is the outcome of what was at one time called animal magnetism, and is governed by the facts that certain men can exercise a personal influence over other persons, and that psychical states can be induced by certain physical processes. Both of these facts have long been recognized, but it is upon the application of them the schools of Nancy and Charcot are engaged. The soothsaying by means of precious stones, divinating by gazing into crystal vessels, the strange feats among the Indian yogis and fakirs, the recognized influence of one human being upon another, the laying on of hands, the exercise of sorcery and witchcraft, have all been traced to the influence of the hypnotic state. Gradually these isolated facts were reduced to a system, and the doctrine of the influence of the stars upon men, known as astrology, was put forward. This influence was then applied to disease, and it was taught that men possessed the power by means of which they could affect the sick.

This theory was elaborated as early as 1600, and the assumption was made of a vital spirit of the universe by means of which all bodies were related to each other, or as Mesmer afterward called it, the universal fluid. General attention was not drawn to animal magnetism till the time of Mesmer, a Viennese doctor, now dead eighty years. He issued a circular letter to the academies maintaining the existence of animal magnetism, by which persons could influence each other, and advocating its use in disease. The Salpetriere men recognize the work of Mesmer and have nothing but praise for it. One of his followers discovered a state known as artificial somnambulism, characterized by a sleep in which the ideas and actions of the magnetized person could be directed, but it does not appear that Mesmer was aware of such a condition. In Germany the new doctrine was much disliked, but gained ground. In Austria it was absolutely forbidden. In the outset magnetism was scientific, then it became mystical, and this led to its downfall. But the school of Nancy is again bringing forward the critical side, which may end in its establishment as a curative agent.

In 1815 a Franco-Indian showed that no mysterious force was needed for the production of the phenomena and that the cause of the sleep was altogether subjective in the person who was to be put to sleep. Five years later experiments were undertaken in the hospitals of Paris, and a commission was appointed by the Academy of Medicine to examine the question. It worked for six years and pronounced a favorable opinion. But an unscientific hankering after mystical things brought discredit upon the work, and the Roman Catholic church formulated a decree against it.

It was reserved for England to mark the difference between animal magnetism and hypnotism, a term not yet used. Braid, of Manchester, confirmed the view that the phenomena were subjective, and using the term hypnotism he set it in an independent place by the side of mesmerism.

Even this early hypnotism was used therapeutically to perform surgical operations without pain. In America animal magnetism gained a foothold, with New Orleans for a center, and Grimes obtained the same results as Braid, working independently. In 1850 another American, Darling, came to England and proved the identity of electro-biology with hypnotism.

The founder of the Nancy school was Liebault, who published his work in 1866, and in 1878 Charcot began his public lectures. It was only when the school of Nancy took up the subject that the interest became general with Bernheim at its head. Examples of the curative effects of hypnotism were given, and some of the teachers worked at its physiological side, others at the forensic side of the subject. Hypnotism is now upon a sure basis and has investigators in every country, particularly in the north of Europe, while in England there is the Society for Psychical Research, and another in the United States affiliated with it, and having a similar name. In the South American states as well much work is being done. In most of the German universities lectures are delivered on the subject by distinguished physiologists and psychologists, and only last year a congress was held in Paris, where the opinions on the subject were collected, and where the views of the Nancy school predominated.

Here are some of the experiments seen in the course of a morning at the Salpetriere. A young man was seated on a chair and a small stone at which he was to gaze fixedly was given to him. In two minutes the eyelids began to droop, and in a minute more his eyes were closed fast, his hand dropped powerless by his side. The experimenter assured him that he could not open his eyes, and he tried in vain. Then he blew upon his eyes, and the lad resumed his normal condition, feeling only a little fatigue.

The second experiment was upon a younger boy. The experimenter directed him to look straight in his eyes, and after he had done this for some time led him by the hand. The experimenter raised his hand, the boy did the same. He directed him to kneel down, the command was obeyed. He tried to rise, but could not do so as long as the operator continued his gaze, but resumed his position when the spell was removed.

The third experiment was upon an elderly woman. By a series of passes before her face and body she was made to sit quietly with eyes closed, breathing deeply and quietly. From the commands given her and the way in which they were obeyed it appeared that all movements were impossible excepting those that were permitted.

In the fourth experiment the hypnotic state was induced by calling up in the mind an image of sleep, and is the method used exclusively by the Nancy school. The patient is deprived of his will, the various movements are prevented, and his perceptions are also controlled. He hears music, believes he is surrounded by animals, and fondles and caresses objects thinking them to be alive. But he is only obedient to the will of the one who is operating, and quite heedless of the commands of others in the room.

The following experiments were observed in Leeds in the rooms of a firm of dental surgeons. Similar ones were performed by Dr. Bramwell in the office of Carter Bros. & Turner, and witnessed by thirty physicians. A woman was hypnotized and told she was to have three teeth extracted without pain, and that she was to be obedient to all the commands of the operator. The teeth were removed, there was no cry, not even an expression of pain in the face, and when told she was awake, she said she had felt no pain, nor was there any soreness in the gums. A girl of twenty was next made subject to the hypnotic influence, and a large abscess extending into the cheek was scraped thoroughly without pain. Each day afterward the cavity was washed out and dressed painlessly under suggestion.

Another patient was rendered insensible to pain by the following letter from her physician, addressed to the dentist.

"I send you a patient with inclosed order. When you give it to her she will fall asleep at once, and obey your commands."

The order simply said:

"Go to sleep by order of Dr. Bramwell, and obey Mr. Turner's commands."

Sleep was induced by reading the note, and was so profound that, at the end of an operation, in which sixteen stumps were removed, she awoke and insisted that she felt no pain, and that there was then no pain in her mouth. Another girl of fifteen had both tonsils removed while in the hypnotic state, the girl, by suggestion of the hypnotizer, obeying every request of the operator, though in a condition of complete anæsthesia.

At the same meeting, Dr. Clifford Albutt sent a letter reminding those present that thirty years ago Lister performed serious surgical operations, using hypnotism as the anæsthetic. As an example of the control of the sensations which the operator can obtain, a patient was selected and given a drink containing two teaspoonfuls of wine of ipecacuanha, a powerful emetic, with the assurance that it was a pleasant draught. He was further informed that no unpleasant effect would follow, and the man had no symptoms of nausea. The negative effect of other drugs, including castor oil, was also well marked.

In the experiments, even the vessels and the heart were shown to be affected, and the pulse slowed from 98 beats to 92 and increased again to 115. Respiration was also affected, and on the mere suggestion to the patient that he could not breathe respiration was suspended for three minutes, and it is believed death could be caused unless the spell were removed. The temperature of the body was also reduced by 4° when tested by the thermometer.

There was not the same opportunity of witnessing the anatomical changes induced by suggestion during hypnosis, but from the records of the Saltpetriere they are as well authenticated as the others. Cases are recorded in which some object like a cigarette case was applied to the patient's body, and the patient told the skin was being burned. A well-defined blister rose, and the marks remained for a long time. When the object was placed upon the left side of a hysterical patient, anæsthetic on the right, the burn has appeared on the right side also as clearly as if it were reflected in a looking glass. Bleeding at the nose or even from the skin has also been induced, the scar of which was visible after several months. The literature of the Roman Catholic church is filled with accounts of this miraculous bleeding in persons who were gazing intently upon the crucifix. These wounds went through the usual processes of inflammation, with its redness, swelling, heat, and pain, but these were lessened in a marked degree when they were rendered painless by suggestion. Dr. Moll attests to the truth of these experiments performed not at this hospital, but in the lunatic asylum at Zurich by Dr. Forel, which go to show that the mind is a thinking as well as an organizing power.

The Nancy school is particularly strong on the psychological side of hypnotism, but to attempt to understand its theories of the retention of ideas, "speaking with tongues," hallucinations and delusions, and other strange mental states, would lead one into a wilderness of speculation.

The physical methods of inducing hypnotism at the Saltpetriere are various, and include a stimulation of sight, hearing, and touch, though smell and taste have been tried, but with not much success. The method of Braid is to fix the gaze on some object, such as a coin, the finger, or the eye. Luys uses a mirror made to revolve rapidly, and others employ the ticking of a watch. This calls up the methods employed by uncivilized people to induce conditions analogous to hypnotism. Among the Laplanders a magic drum is used, and other races make use of a rhythmical song, but Charcot himself sometimes uses the noise of a gong or a flash of limelight. Various Arab tribes, by dancing and singing, throw themselves into a state of ecstasy, in which their bodies are insensible to wounds. They cut and pierce themselves with knives and are said to experience much comfort as a result. The dervishes of Constantinople are another example of this fact.

The Nancy investigators use whichever method is considered suitable to the individual case. The waking, or dehypnotization, as they call it, occurs either by acting on the imagination or by stimulating the senses, as one wakes from a natural sleep by habit or resolve to awaken, or by hearing a loud noise. They consider the condition of lethargy in which one may remain asleep for several days as distinct from the hypnotic state. An enormous number of cases have been collected to show what conditions favor a submission to the strange influence, and it has been proved that neither hysteria nor feeble health nor general weakness predisposes to it. Intelligent persons are more readily hypnotized than ignorant ones, and the mentally superior more than those who are dull and stupid.

The disposition to hypnosis as a sign of weakness of will is of no value, but the influence of heredity is marked. Children under three cannot be influenced at all, and even those under eight are hypnotized with difficulty. Sex has no influence either way, but clim-

ate has, a warm temperature being more suitable than cold. A subject submits the more easily with each attempt, but there are cases where forty attempts were successfully resisted. The variation in susceptibility to hypnosis is attributed to mistrust and lack of experience, but at this hospital, where the very air is full of it, it is believed that everybody is hypnotizable if only the attempt is continued long enough, and that no special or peculiar aptitude is necessary for success in experiments. Liebault hypnotizes 92 per cent. of his patients.

The present interest in hypnotism is due to its possibility as a therapeutic agent, and doctors are impressed with this belief. Such an investigation was necessary as the Nancy school has undertaken, and it was the first to recognize that the value of hypnosis lies in the increased susceptibility it gives to suggestion, but that the two are entirely separate. The knowledge of the effect of the mind in the cure of disease is as old as disease itself. All that hypnosis aims to do is to allow the mind freer play. Ancient medicine, which was confined to the priests, is full of this belief. What else is the explanation of the cures effected at the shrine of La Bonne Ste.-Anne—for cures they are—in Quebec and in other consecrated places by the men in every century but our own, who effected more cures than the physicians themselves, and yet are denounced as swindlers?

It was left to the Nancy school to use suggestion scientifically in medicine, though in many quarters it is greeted with laughter, just as massage, galvanism, vaccination, and cold water were laughed at, and no wonder when men like Koch and Brown-Sequard fathered the frauds that bear their names. The men of the Saltpetriere court opposition as a means of arriving at the truth, bearing in mind that those authorities who have spoken against them may be authorities in their own departments and yet no more capable than laymen of pronouncing upon cure by suggestion. All that the Nancy school asks is that the subject be investigated. It has not asserted that it has found or is likely to find a universal panacea. Many physicians affirm that hypnotism is the work of charlatans, but the Nancy school retorts that, though medicine itself is successfully practiced by many charlatans, it should not be left entirely in their hands. The dangers of hypnotism are also urged, but, while its upholders do not affirm its absolute safety, they retort that neither is the use of other remedies, such as chloroform, chloral, morphia, and carbolic acid, unattended by dangers. Even surgical operations are far from safe. Their only plea is to make of hypnotism not an amusement or a scientific toy, but a serious remedy for the cure of disease.

The Salpetriere investigators hold that the bad effects that sometimes follow the hypnotic condition are due to its improper use; that it induces nervousness in healthy persons and makes nervous persons worse because improper suggestions have been made to them, such as persuading them that they have witnessed a serious fire; and they compare the bad effects to one's ill-feeling after having had an unpleasant dream. They urge that the patient be properly and completely awakened by using some soothing formula, such as this: "Now, you are going to awaken presently and will feel quiet and comfortable," and recommend that continued stimulation of the senses and exciting suggestions be avoided, and that all trace of it be removed before waking.

But there are real dangers; even the Nancy school admits it. The chief one is the increased tendency to hypnosis, and the possibility of inducing the condition against the patient's will. This is avoided by a counter suggestion to the patient that nobody will be able to hypnotize him without his permission, and this always proves an effective check. Another is that its long continued use may be injurious. Against this the school says that many drugs may cause chronic poisoning, and quotes the experience of Liebault, who has used the method therapeutically for thirty years, and has experienced no bad results. Again, its opponents urge that the mysteriousness of hypnotism should preclude its use, yet they do not object to using a drug because they do not understand how it acts. Indeed, every practitioner sends patients to springs and such places just for their mysterious effect, and from one of the hospitals of Paris sixty patients are sent yearly to the Shrine of Lourdes, and some of them are benefited by the visit.

But there are real dangers attending its practice by unscientific persons, and cases have occurred here in which the subject lost the power of speech, then passed into a condition of catalepsy, and finally of convulsions. He had been hypnotized by being made to look at a bright crystal, with the result that any glittering substance would induce the condition against his will of what they call hysteria with maniacal excitement. Though he was treated with all the known sedatives—chloral, bromides, sulfonal, and morphine—the convulsions were repeated, followed by a sharp attack of fever, which lasted ten days and ended by recovery in three weeks. The physicians attributed the symptoms to congestion of the brain, and said that it proved how dangerous it is for persons to allow themselves to be made the subjects of exhibitors for the amusement of an audience.

The question finally is: Have suggestive therapeutics been followed by good results? On this point one can only take testimony and weigh it, and, if human testimony and the results of experiment and personal observation be worth anything, then it must be concluded that good and lasting effects have followed. This is particularly true in cases of nervous disorders not founded on anatomical derangements, headaches, stomach pains, rheumatic and neuralgic affections, sleeplessness, paralysis of the limbs, somnambulism, unpleasant dreams, loss of appetite, the alcohol and morphine habits, stammering, disorders of vision, noises in the ears, chorea, melancholia, and writer's cramp. The use of hypnotism for surgical purposes is not highly credited at the Salpetriere, though it has been employed in the Paris hospitals since 1821, and in Calcutta and in many other places a series of cases was published where the method was employed successfully in obstetrical cases, but of these no information was to be obtained at first hand in this hospital.

Another aspect of the question is the relation of hypnotism to crime, as the offenses to which hypnotic subjects are exposed are important. A collection of such cases has been made dating from 1831, and the opinion of experts is given that assaults might be committed against the patient's will and without her consciousness. Yet the loss of memory is only temporary, and the subject may at any time call up the occurrence, just as a chance word may remind one of a dream. It is admitted that loss of memory and paralysis may be caused with bad intent, and that even the idea of suicide may be so firmly implanted in the mind as to make the subject at some future time destroy his own life. People can even be induced to sign notes and alter their own wills.

Now, if such an act were committed as a post-hypnotic suggestion, that is, as a result of a suggestion made in the course of the hypnotic state, but carried out after it had passed off, in how far is the subject responsible? This is a question which the French jurists have not solved, and the doctors can give them very little help, though they declare that if hypnosis is a state of mental disease, then all actions in the hypnotic state must go unpunished, and one of them adds that a person is punishable because he might have foreseen the possibility of such a suggestion.

These investigations have proved that hypnotism is in no way useful as a means of justice. Apart from the unwillingness of a presumably guilty subject to undergo the ordeal and the practical difficulty of administering the oath, persons in this condition can weave as artistic a web of lies as if they were in the witness box. Cases have arisen, notably that of Eyraud the murderer in the present year, in which the accused pleaded that the crime was suggested to him and that he acted under a subjective constraint. The Nancy school proposes to deal with such a case by deciding whether the accused was really hypnotized, whether a suggestion was made to him in this condition, and who made the suggestion.

Hypnotism is forcing itself forward, and has been subjected to legal restraint like vivisection. In Russia it can be done only in the presence of three doctors. In Germany all public exhibitions have been prohibited, and in France there is a movement in the same direction. Gradually it is coming where it belongs, and where its value for good will be sufficiently tested—into the hands of scientific men like those who received a stranger so cordially at the Salpetriere.—*N. Y. Times.*

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